

Pasado y Presente de la Radioterapia

Dra. Silvia Zunino
Instituto de Radioterapia – Fundación Marie Curie
Córdoba – Argentina

Academia de Ciencias Médicas
Córdoba, 15 de Octubre de 2009

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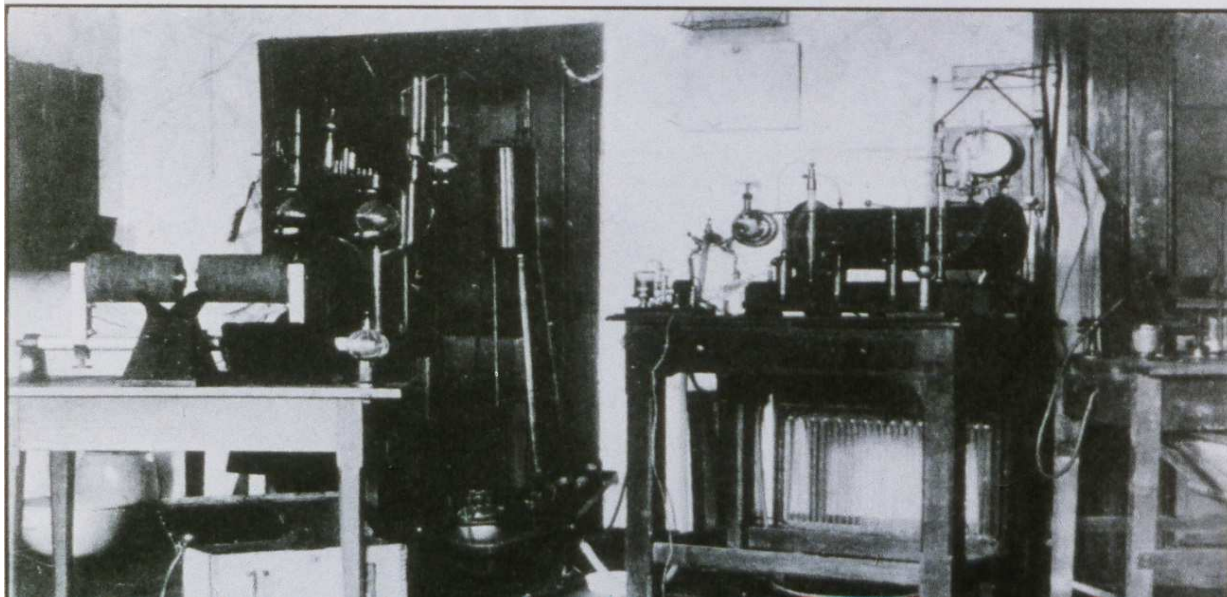
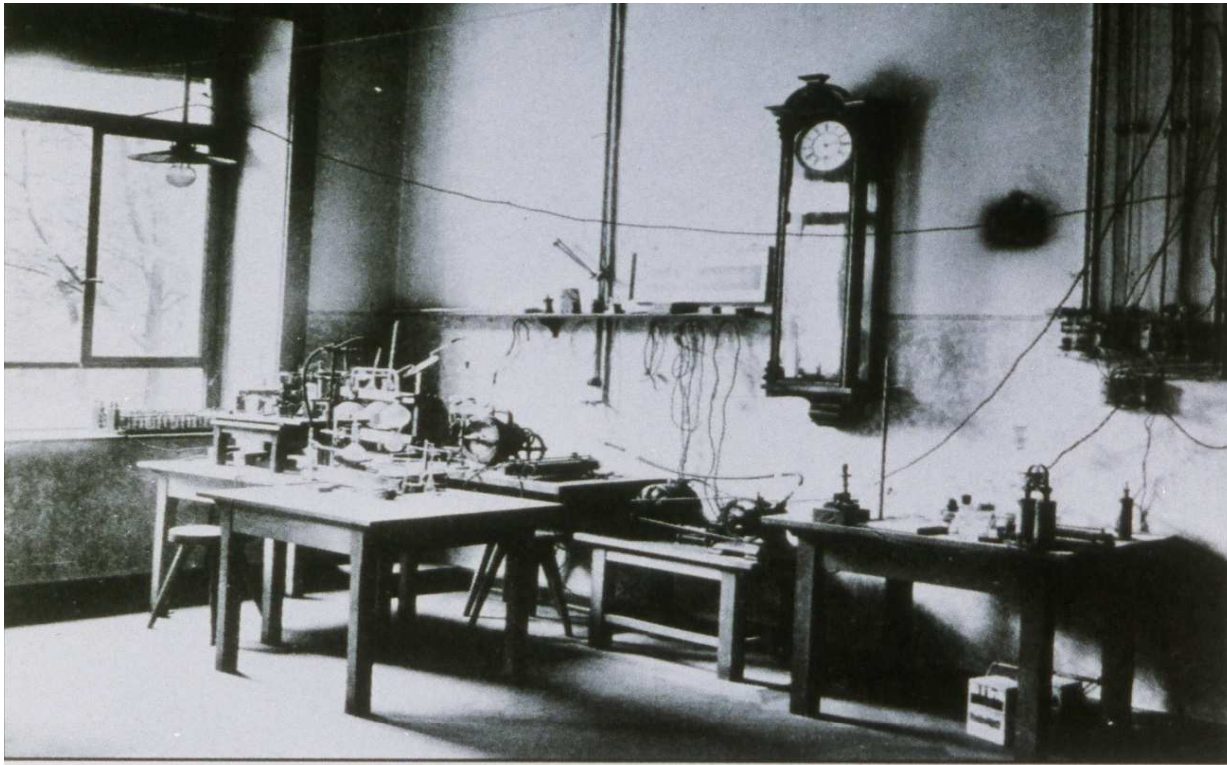
El origen

Radiation Oncology 100 years of therapy and research
ASTRO 1995

Röntgen: 1845–1923

Westphalian - Alemania





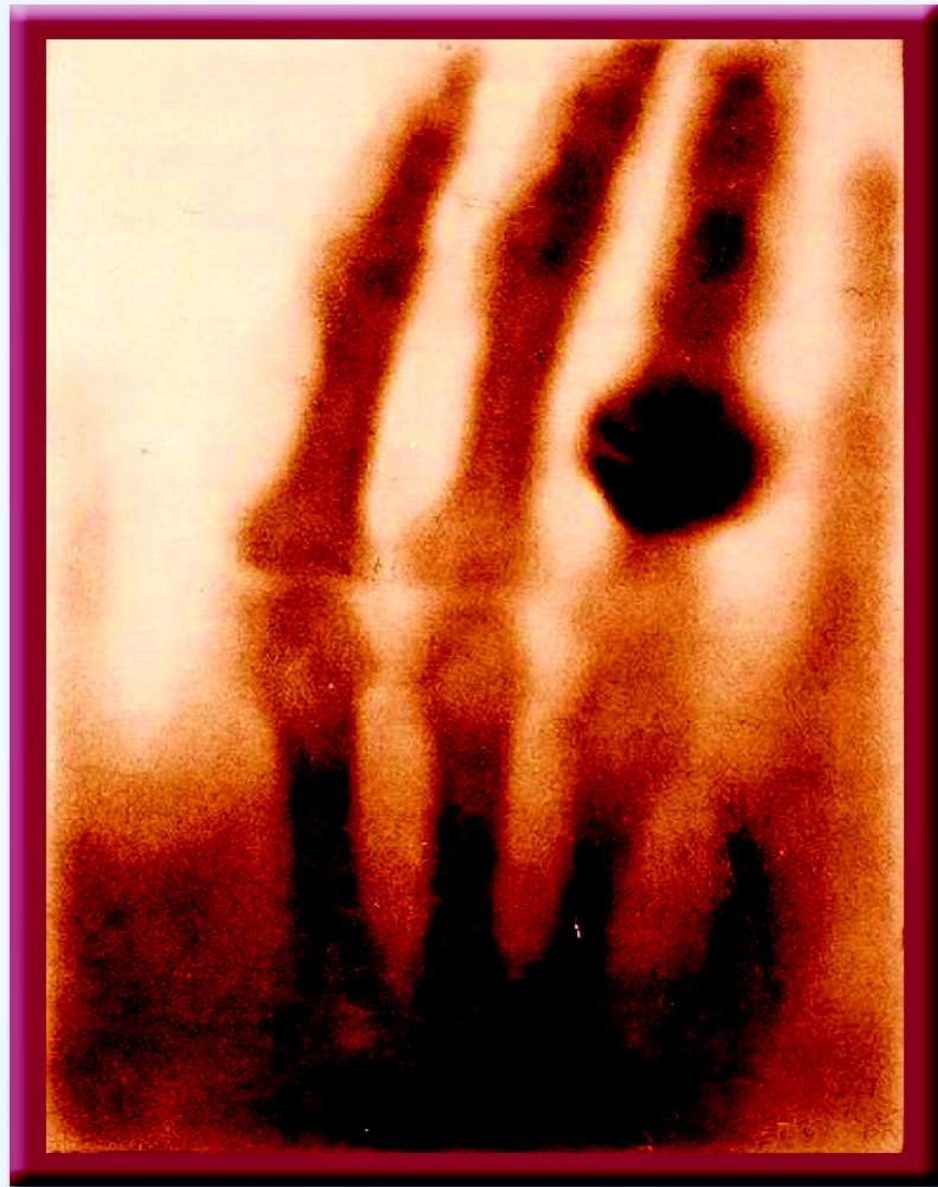
08-11-1895

Röntgen'lab

**mientras investigaba
la naturaleza de la luz
descubrió los
rayos x**

**denominados
“mágicos” “nueva
luz” “cura milagrosa”
rápida difusión de
aplicación**

La primera radiografía de la esposa de Röntgen





**Emil
Grubbé**

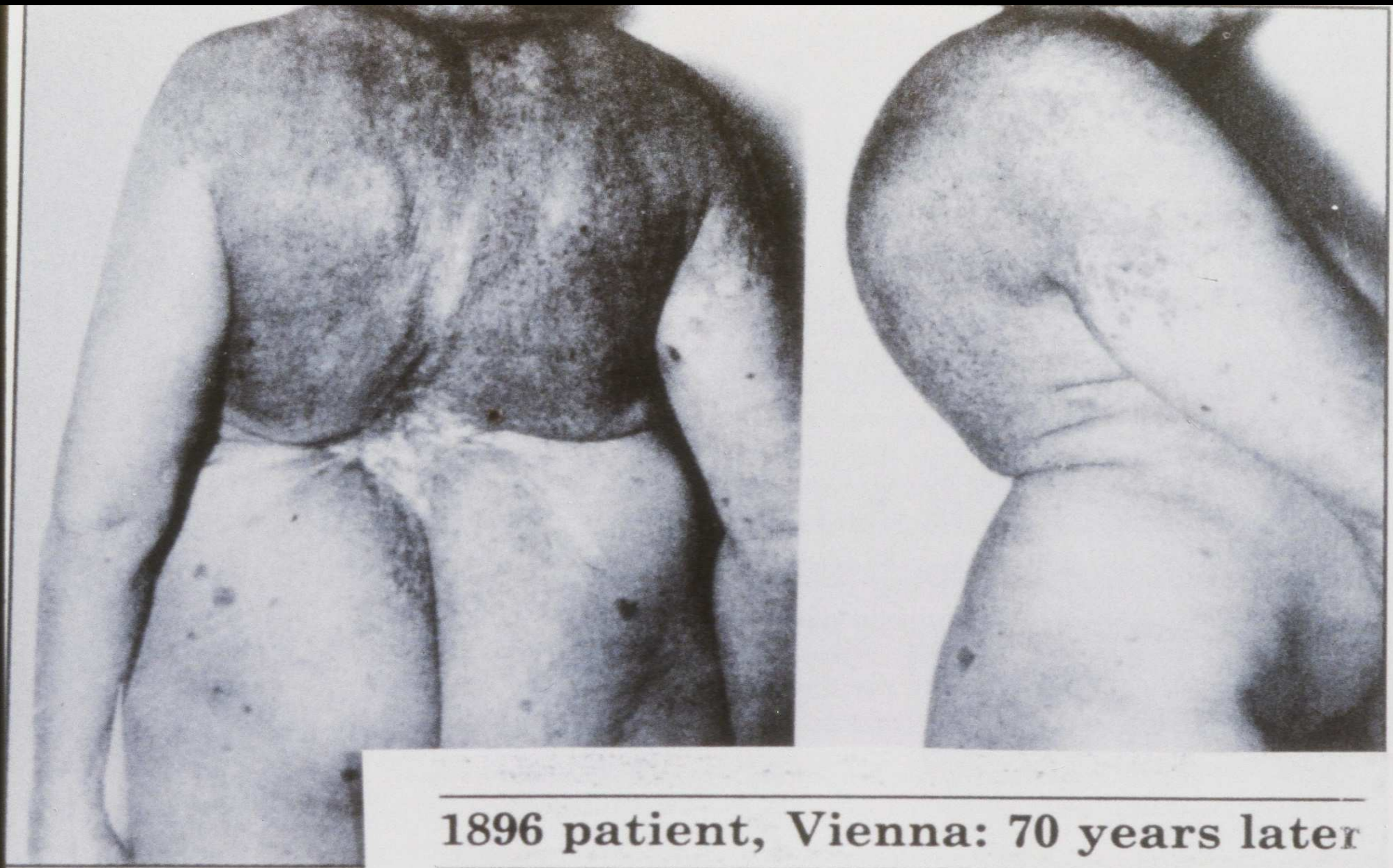
Electrician and metalurgist

Enero 1896 primer Ca. de mama recurrente mujer de 55 a.

Sufrió daño severo por radiaciones

En 1929 le amputaron la mano izquierda

Murió en 1960 por cáncer de piel con metástasis



1896 patient, Vienna: 70 years later

1896- Niña 4 años irradiaron nevus dorsal
Fotografía tomada a los 74 años

H. PRESTON PRATT, M. D., President. R. S. GREGG, M. D., Secretary.

Dr. Pratt's X-Ray
...AND...
Electro-Therapeutical Laboratory,
MASONIC TEMPLE, CHICAGO.
Long Distance Phone, Central 1910.

The Oldest X-Ray Laboratory, established February 7, 1896, is well equipped for

General Electro-Therapeutical Work of all kinds. Dr. Pratt's long experience enables him to guarantee

No Injurious Effects from the X-RAY or other treatments in his laboratory.

X-Ray Pictures, both snap shots and time exposures.

Cancer, Lupus, and other forms of tuberculosis, inflamed joints, and numerous other ailments, are successfully treated.

Interests of Physicians and Surgeons protected.

Expert Evidence rendered in medico-legal cases.

Professional Correspondence receives prompt attention.

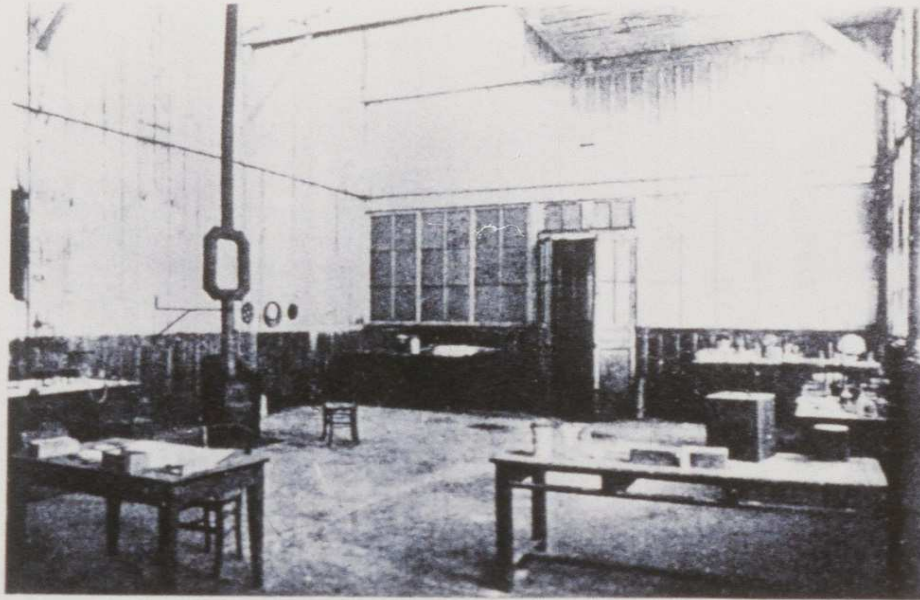
Published Articles on X-Rays and Electro-Therapeutics will be sent on application.

Febrero, 1896

Prácticos
instalaban
laboratorios
de Rayos X

“Marketing”

Radioactividad y Radium



Interior of drafty and leaky shed at the School of Physics where radium was discovered.¹



Antoine-Henri Becquerel (1852-1908).¹



Marie Curie (1867-1934).³



Pierre Curie (1859-1906).¹

1896- Becquerel

Marie y Pierre Curie



Marie Skłodowska Curie

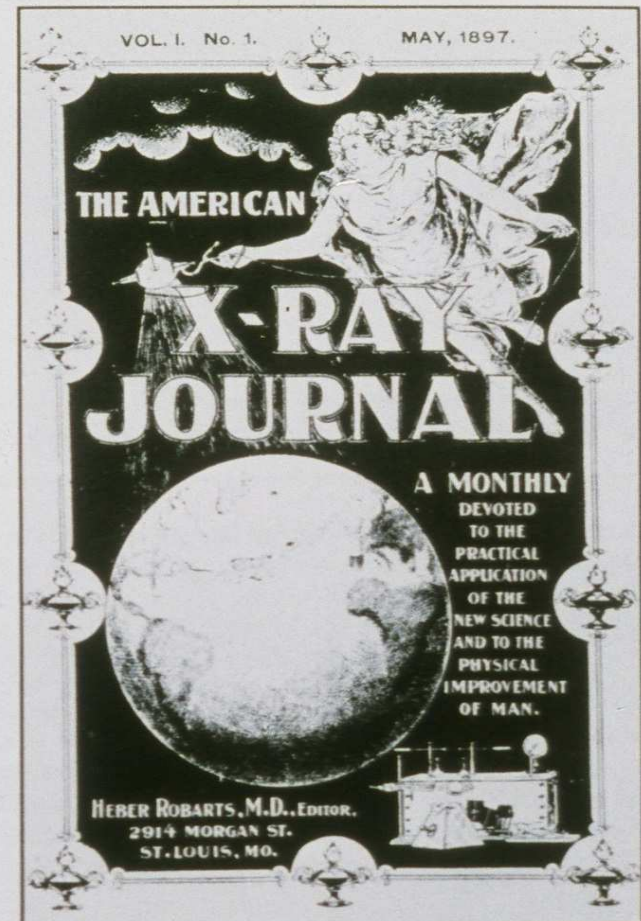
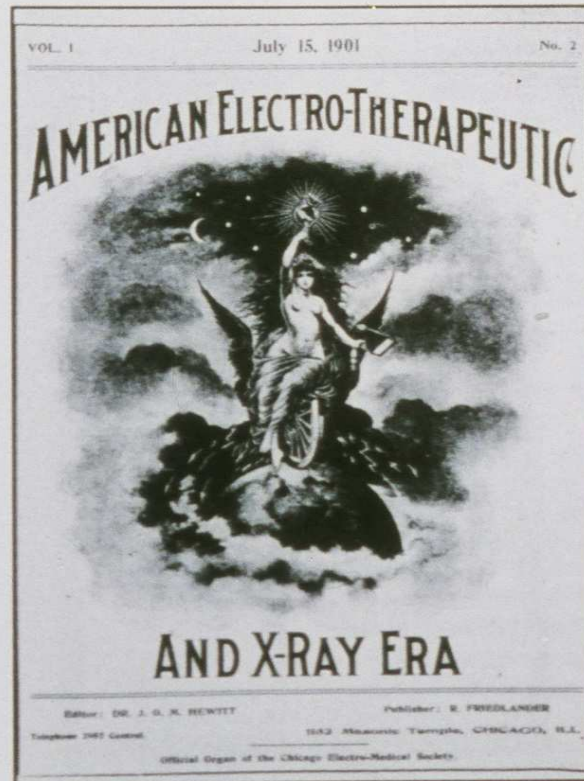
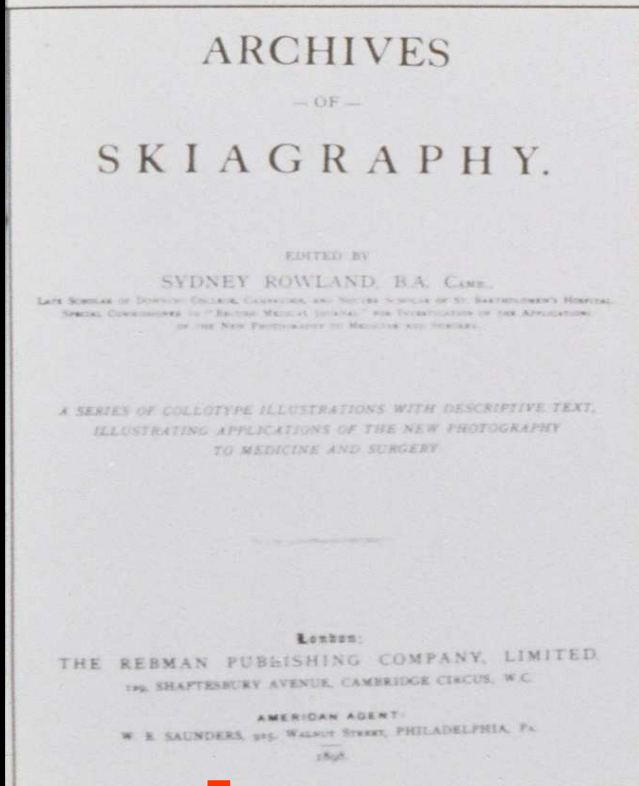
1867 - 1934

Nació en Warsaw - Polonia

- ☐ **Doctora en Ciencias en 1903**
- ☐ **Premio Nobel** en Física en 1903
junto a Pierre Curie y Henri
Becquerel por el trabajo sobre
radiaciones

- ❑ **Premio Nobel** en Química en 1911 por el descubrimiento del radium y polonio
- ❑ Fundó el Instituto del Radium en Paris en 1914
- ❑ Primera mujer profesora de La Sorbona
- ❑ **Primera Mujer** que ganó el Premio Nobel
- ❑ **Unica mujer** que ganó 2 Premios Nobel

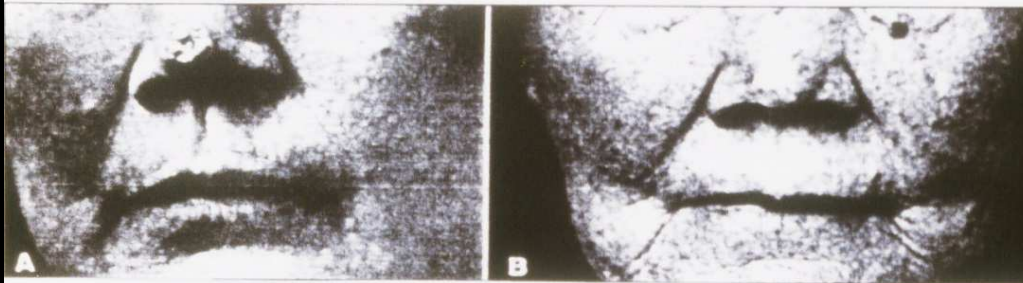
Other early journals



Mayo 1897

later the British Journal of Radiology

First successful treatments of cancer:
Stockholm, 1899



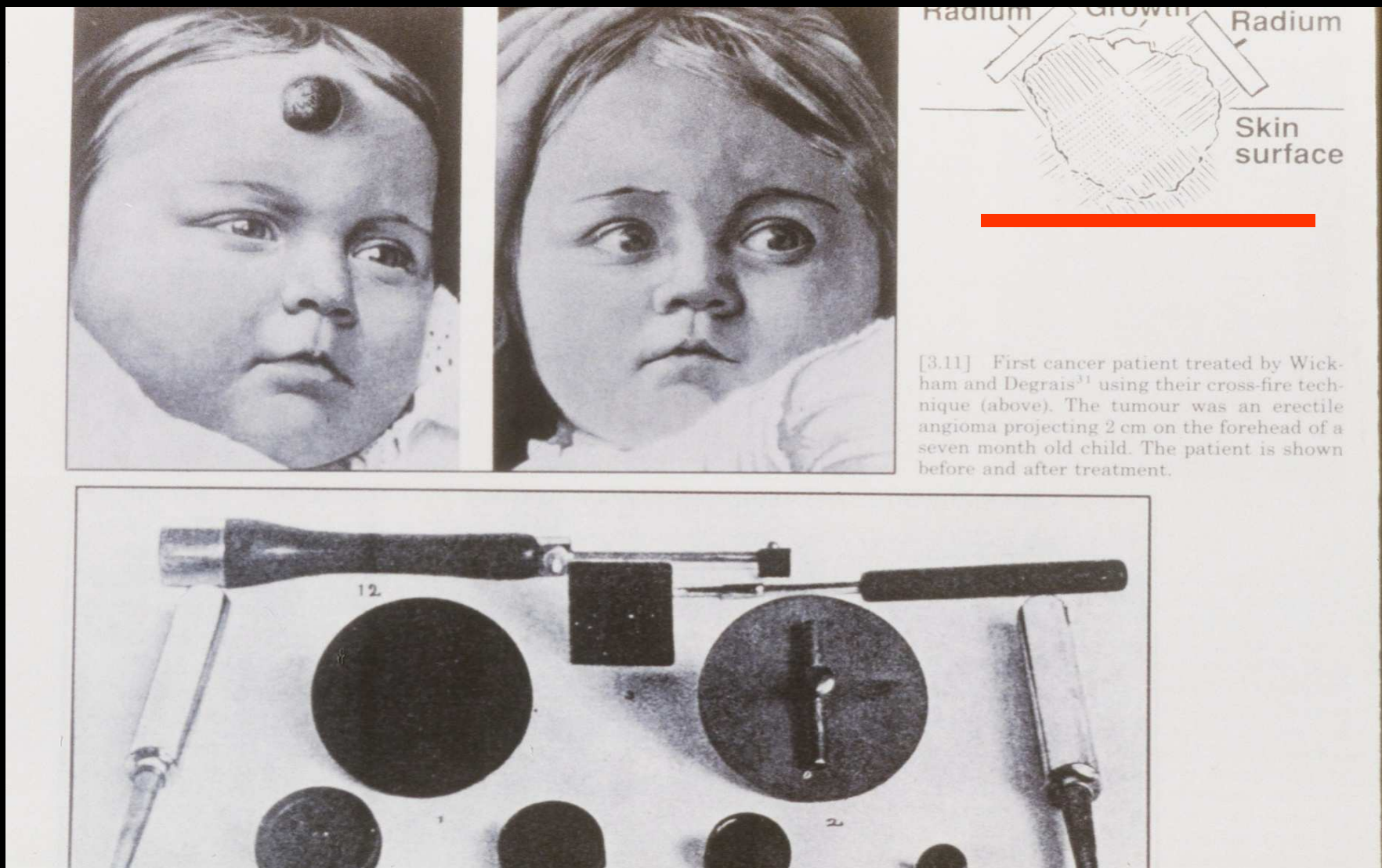
Estocolmo 1899
Thor Stembeck
Mujer 49 años
Carcinoma basocelular
nariz
100 fr. en 9 meses



Tage Sjogren (1899)
Ca. Epidermoide
50 fr. en 30 meses
Curados a 30 años

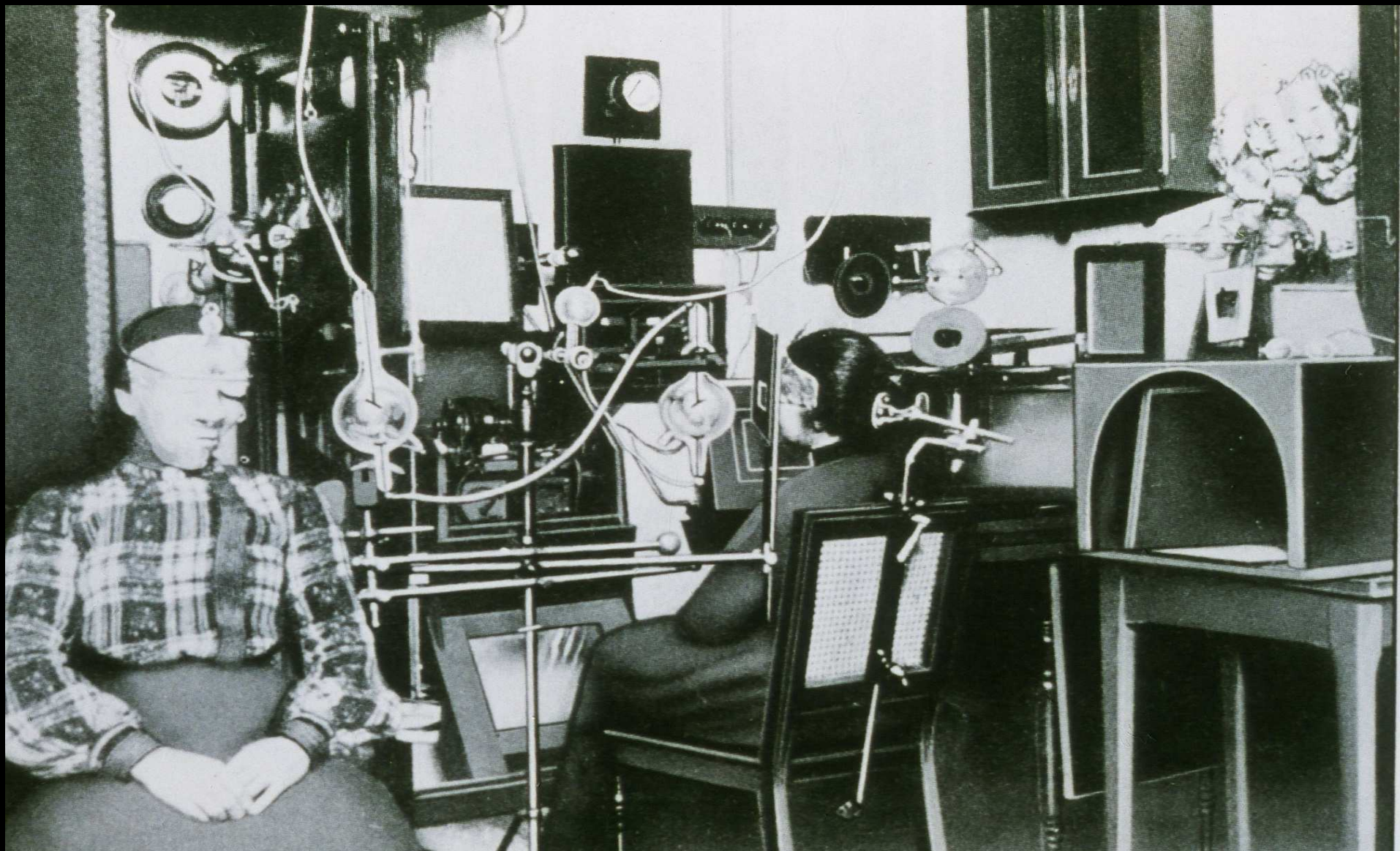
In 1906, Bergonie and Tribondeau equated radiosensitivity to reproductive capacity.¹³

*All physicians have observed with the same interest mixed with surprise that x-irradiation can kill the cells of a neoplasm without impairing the neighboring healthy tissues or even the tissues invaded by the tumor. But experiments on animals have shown that x-rays have a selective action among healthy tissues. For example, in our experiments on the testicle of rat, we have been able to destroy the germinal cells whereas the interstitial tissue and Sertoli syncytium were unimpaired. As a result of these experiments, it has been possible to formulate the following law: X-rays are more effective on cells which have a greater reproductive activity; the effectiveness is greater on those cells which have a longer dividing future ahead, on those cells the morphology and the function of which are least fixed. From this law, it is easy to understand that roentgen radiation destroys tumors without destroying healthy tissues.*¹³

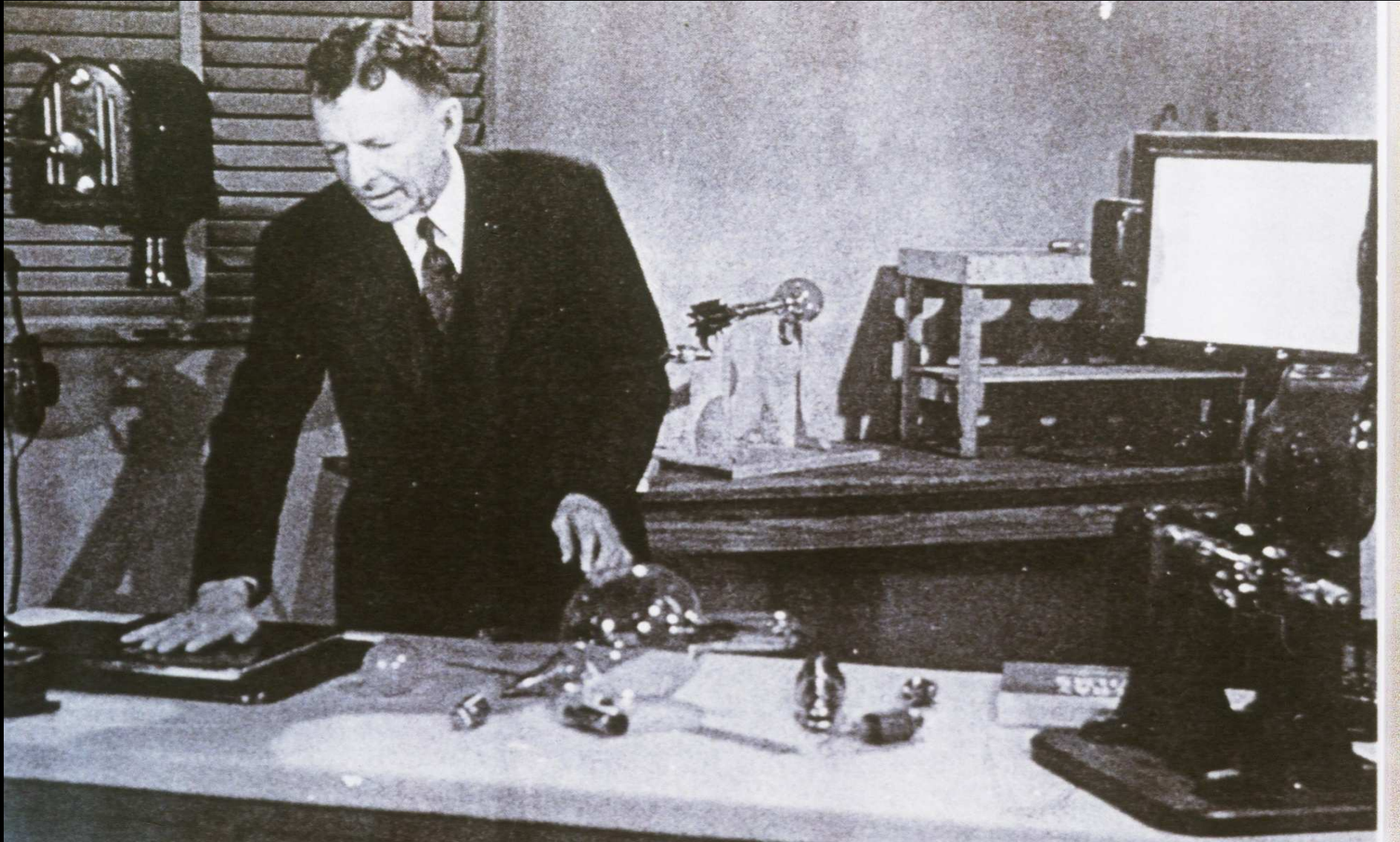


[3.11] First cancer patient treated by Wickham and Degrais³¹ using their cross-fire technique (above). The tumour was an erectile angioma projecting 2 cm on the forehead of a seven month old child. The patient is shown before and after treatment.

Wickham 1907 – Angioma técnica crossfire
Radium - Primeros aplicadores



1910- Consultorio de Radioterapia



1912

Tubo de Coolidge

→ Orthovoltage

1896 a 1912 “extraños y saludables” efectos de los nuevos rayos

- **Depilación del cuero cabelludo por exposición durante el diagnóstico**
- **Eritema**
- **Beneficios en hipertricosis y acné**
- **Más de 100 casos clínicos publicados**
- **Tratamiento de lesiones superficiales y profundas**
- **Uso de rayos x para patología benigna (nevus pediátricos, lupus vulgaris, otros) y maligna**

Befund 14 Tage nach der Bestrahlung.

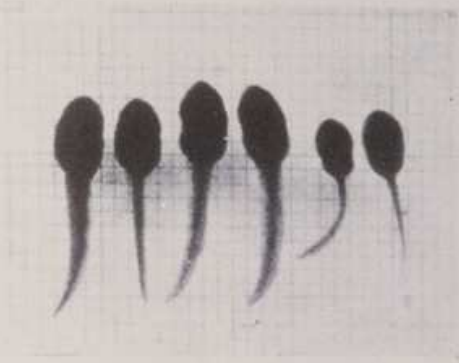


Fig. 1.

Links: 2 mit durch 1 mm Kupfer gefilterten Röntgenstrahlen bestrahlte Larven.
Mitte: 2 Kontrollen.
Rechts: 2 mit Gammastrahlen bestrahlte Larven.

Befund 24 Tage nach der Bestrahlung.

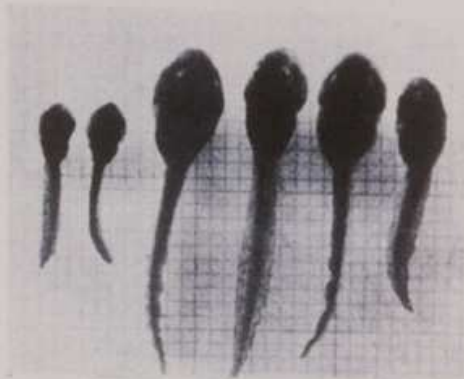


Fig. 2.

Links: 2 mit Gammastrahlen bestrahlte Larven.
Mitte: 2 Kontrollen.
Rechts: 2 mit durch 1 mm Kupfer gefilterten Röntgenstrahlen bestrahlte Larven.

Befund 28 Tage nach der Bestrahlung.

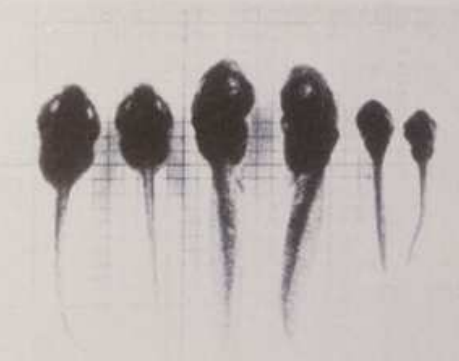


Fig. 3.

Links: 2 mit durch 1 mm Kupfer gefilterten Röntgenstrahlen bestrahlte Larven.
Mitte: 2 Kontrollen.
Rechts: 2 mit Gammastrahlen bestrahlte Larven.

Befund 60 Tage nach der Bestrahlung.

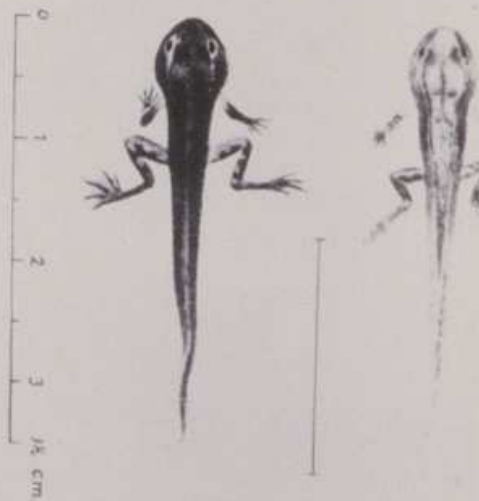


Fig. 4.

Links: 1 mit durch 1 mm Kupfer gefilterten Röntgenstrahlen bestrahlte Larve.
Rechts: 1 Kontrolle.

Investigación de efecto biológico

Kronig and Friedrich's, 1918

Estudio en renacuajos

Igual dosis entregada en

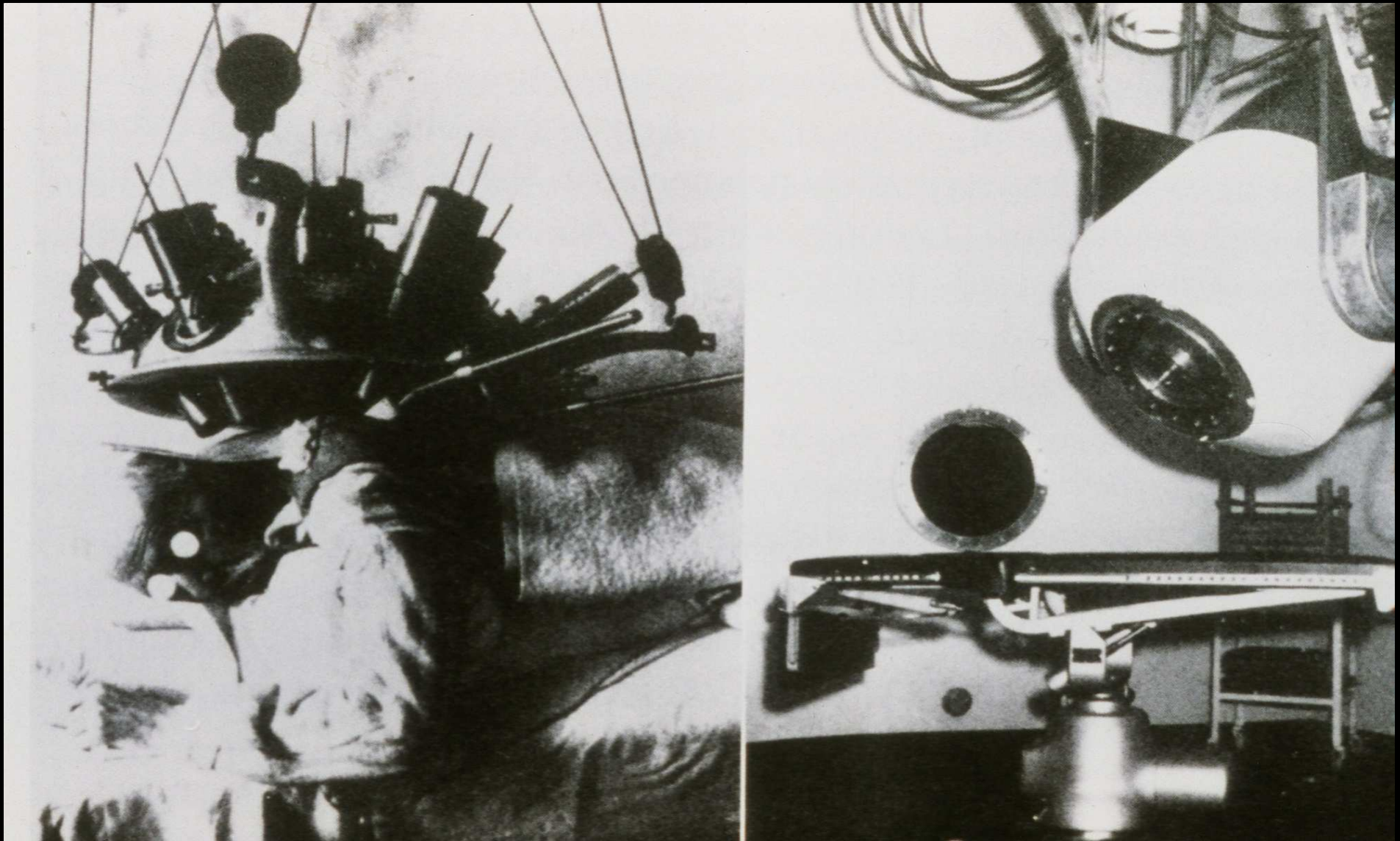
tiempo diferido producian

diferentes reacciones.

Precursores del

fraccionamiento aplicado a la clínica

Pack 1935: tiempo diferente de recuperación entre tejido sano y neoplásico



1930s – Bomba de Radium

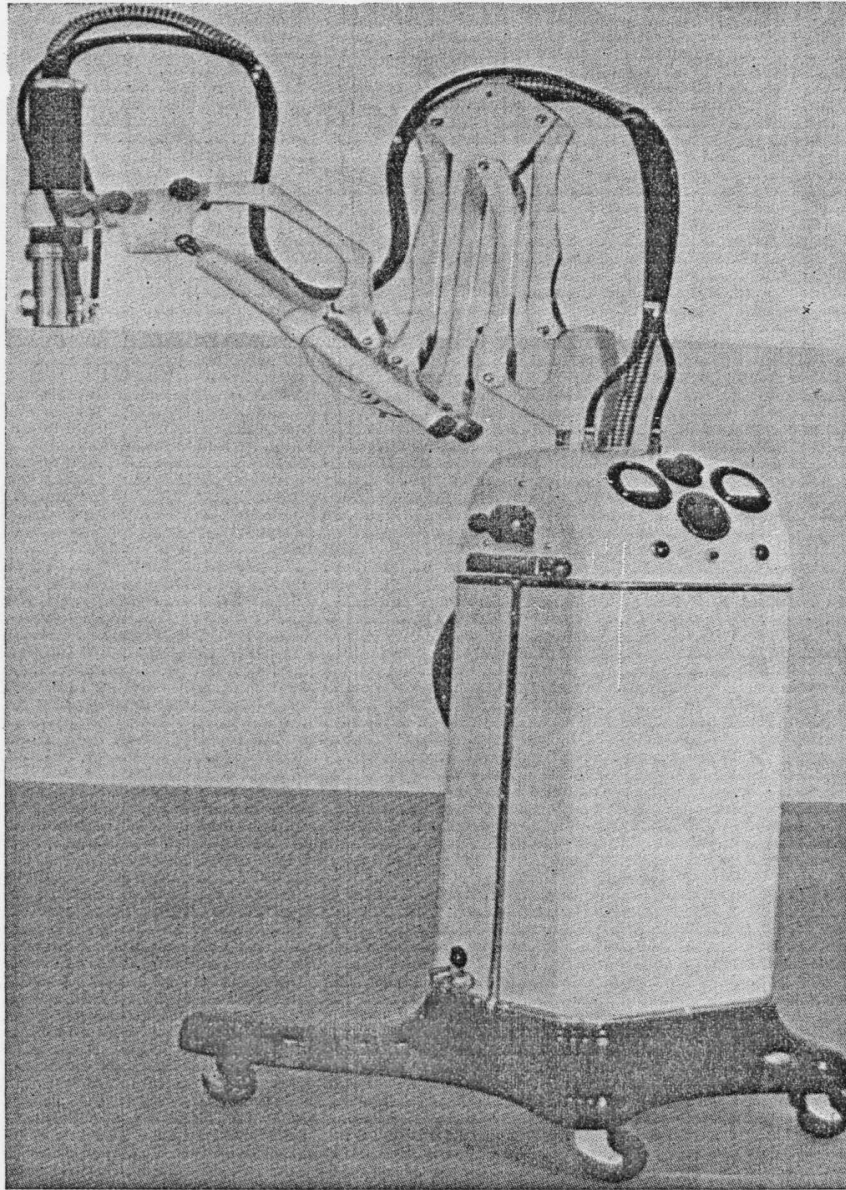


FIG. 157. — Aparato y tubo de rayos Grenz.
(Con autorización de la Westinghouse Electric Corporation, Baltimore, Md.)

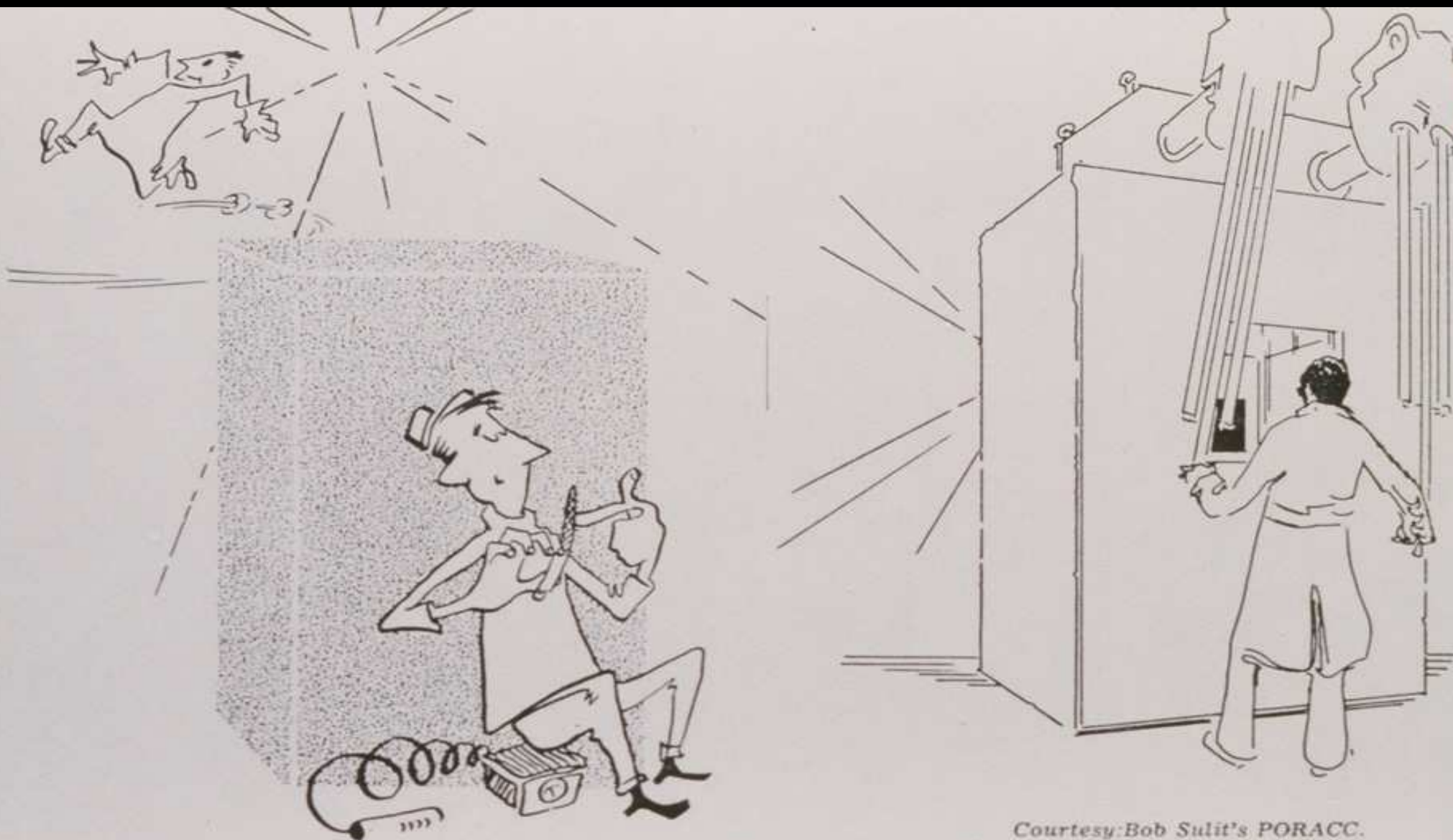
1935
Rayos Grenz
son Rayos
Röntgen de
longitud de
onda muy larga



Sankt Georg Hospital

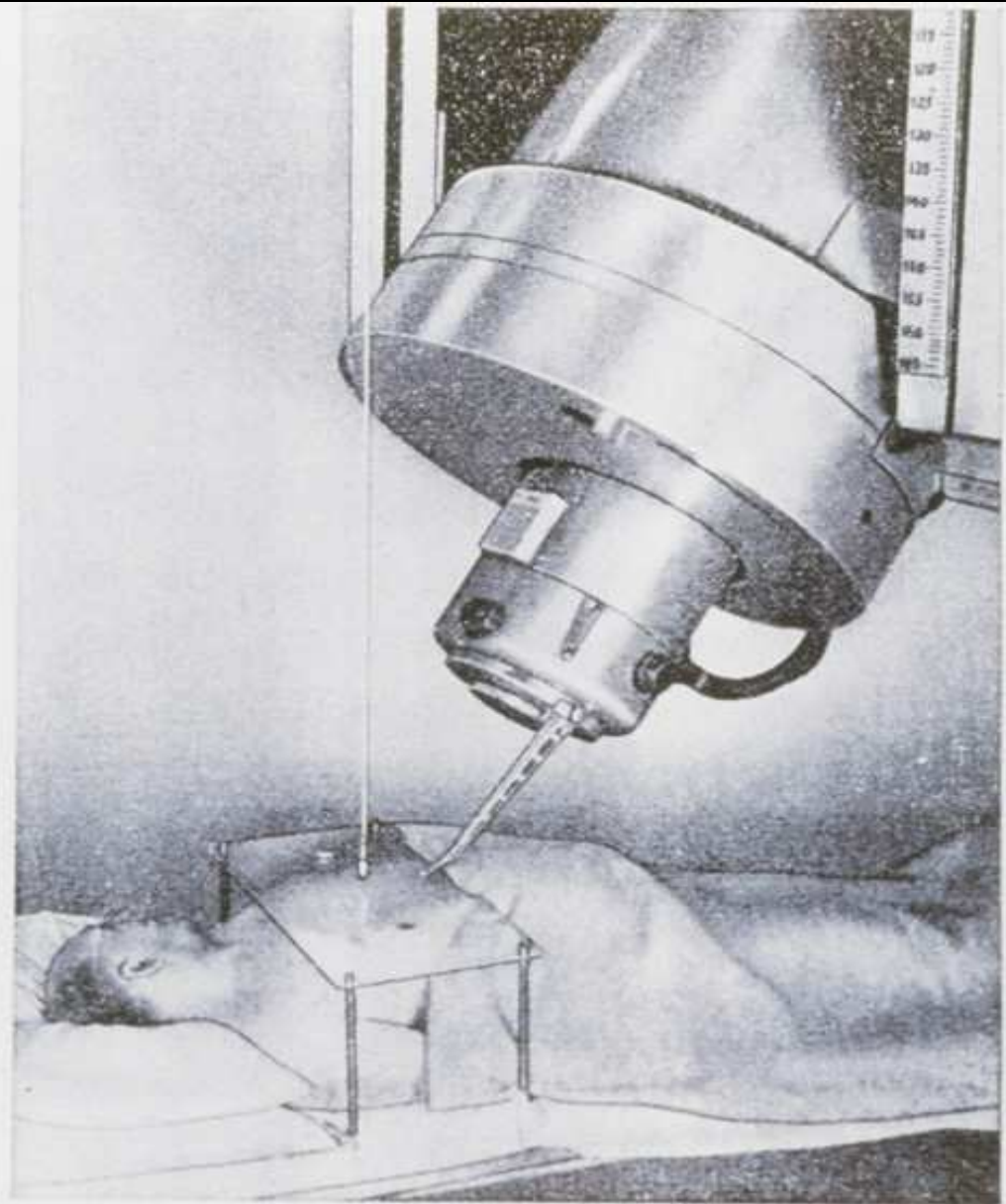
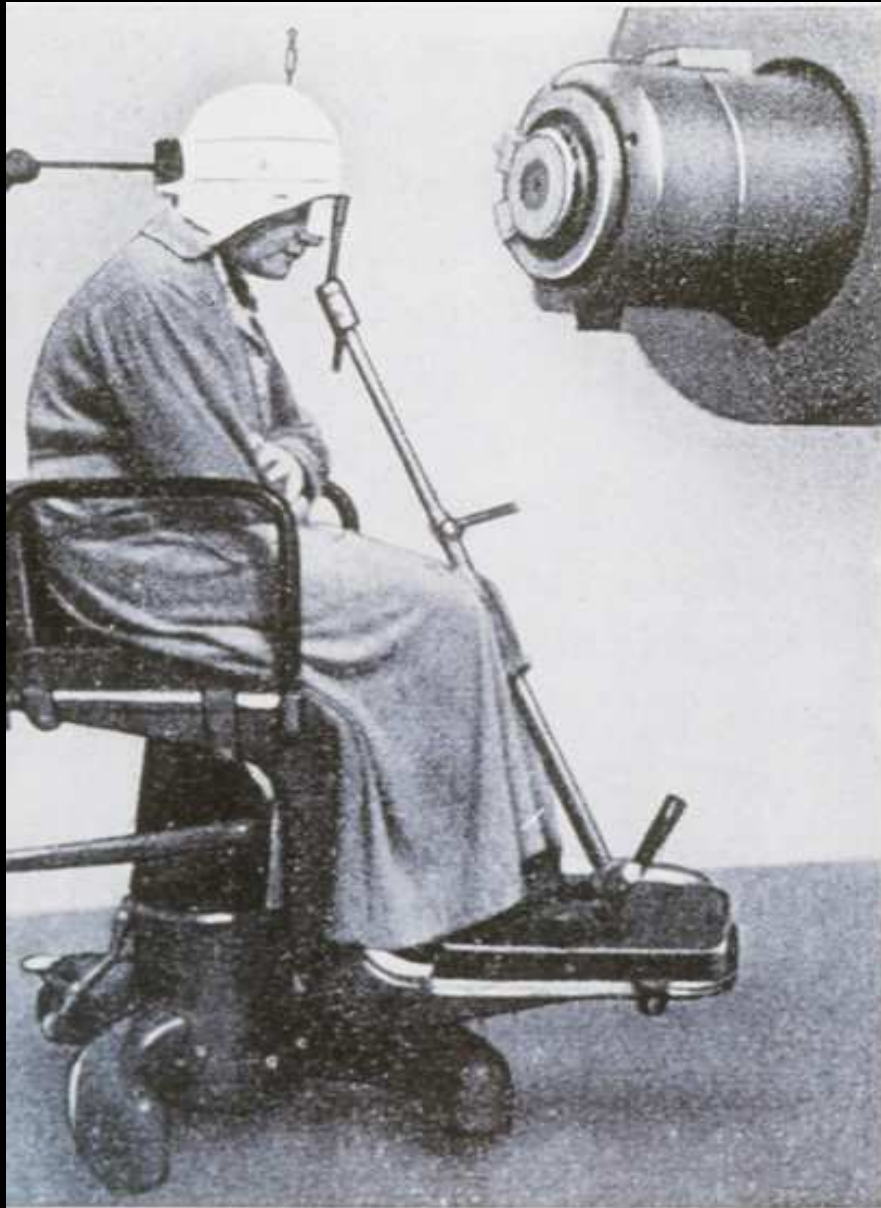
Fig. 12-8. The stelae honoring the pioneers who died victims of their exposures to radiations (1935).

1936- Memorial **159** médicos, científicos y otros, muertos por efecto de Rayos X y Radium en **40 años** de uso



PROTECTION is a matter of distance, shielding, and time of exposure, or a combination of these three factors.

Courtesy: Bob Sulit's PORACC.



1933-1937 Generador de van de Graaff

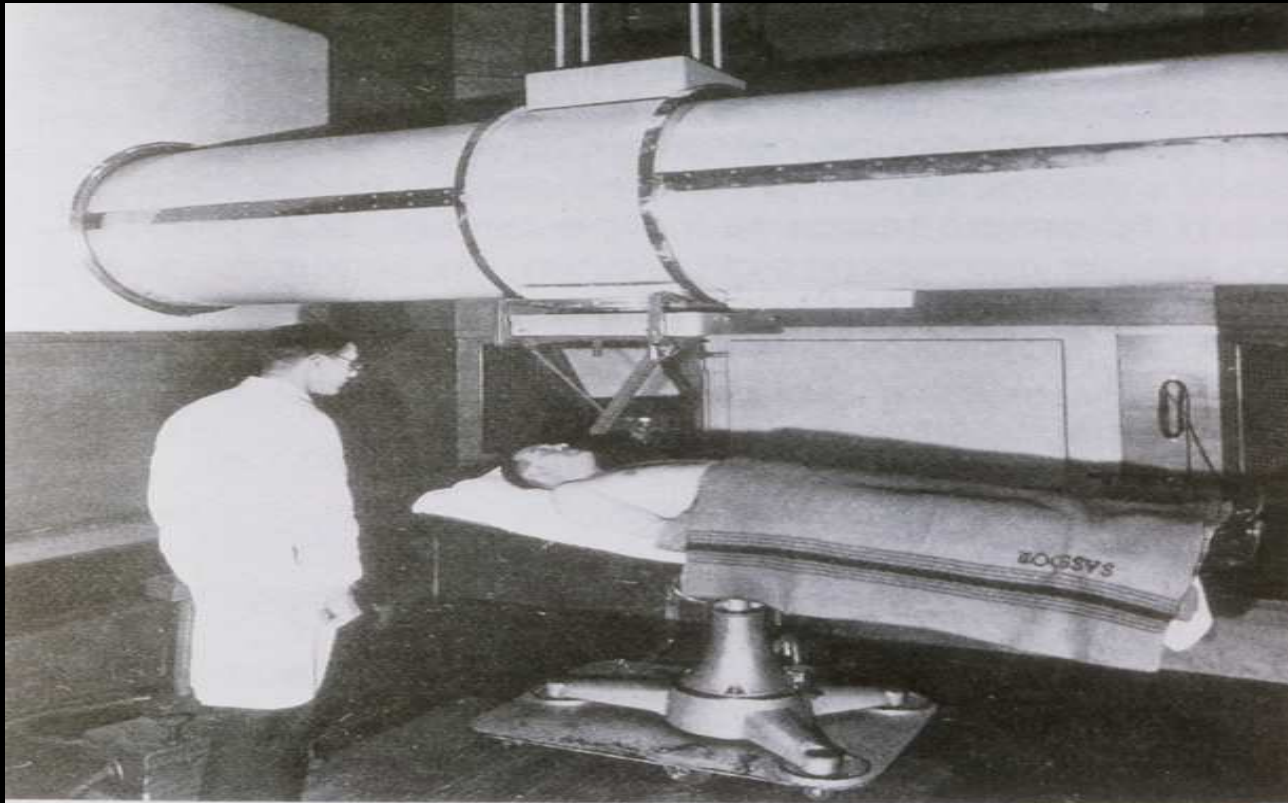


Figure 7

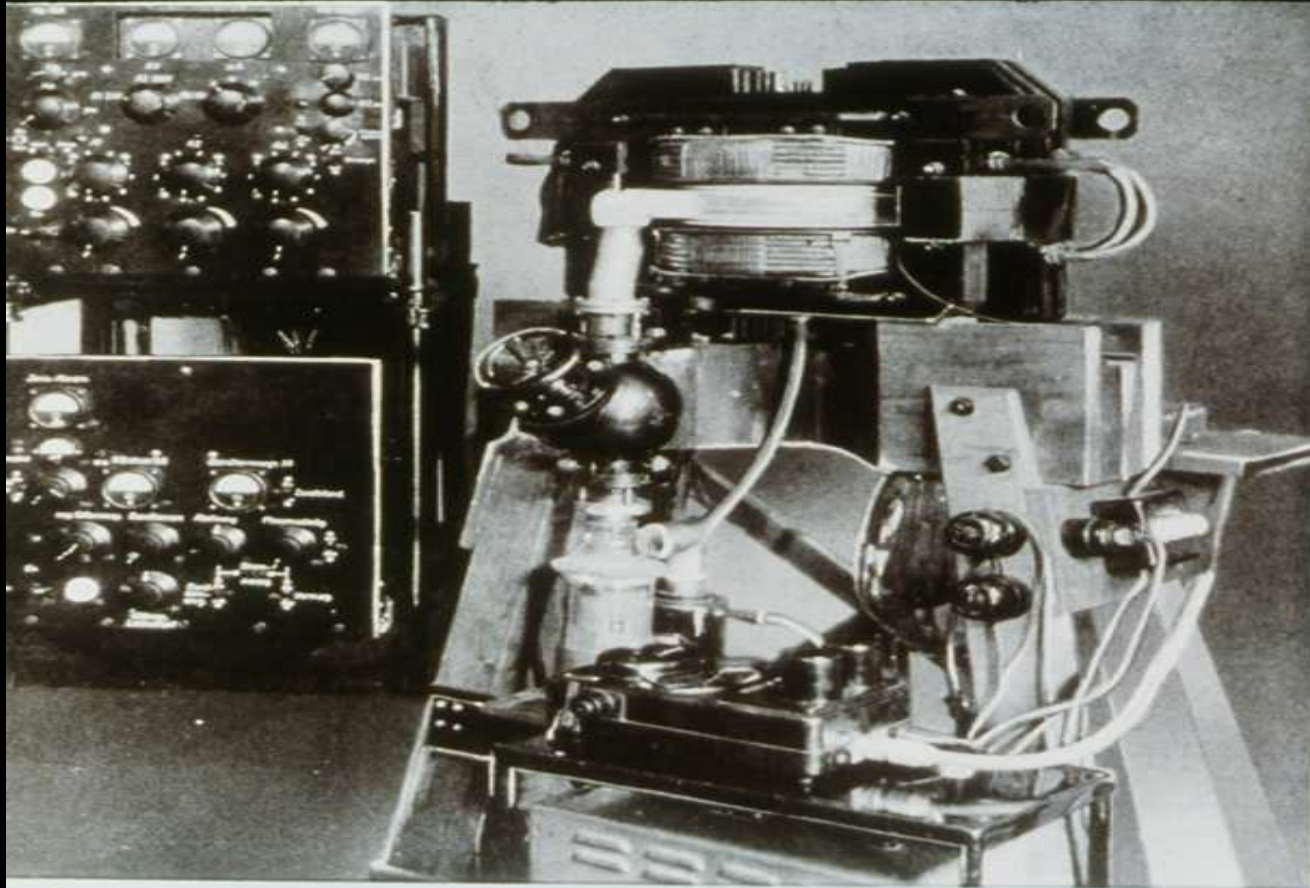
1 MeV therapy installation at St. Bartholomew's Hospital, London (1937). Dr. Ralph Phillips is shown with a patient to be treated by the novel 1 MeV unit. (Courtesy of the British Journal of Radiology.)

**1937- Largo tubo de Rayos X y generador 600 KVp
Campos variables, camilla móvil**



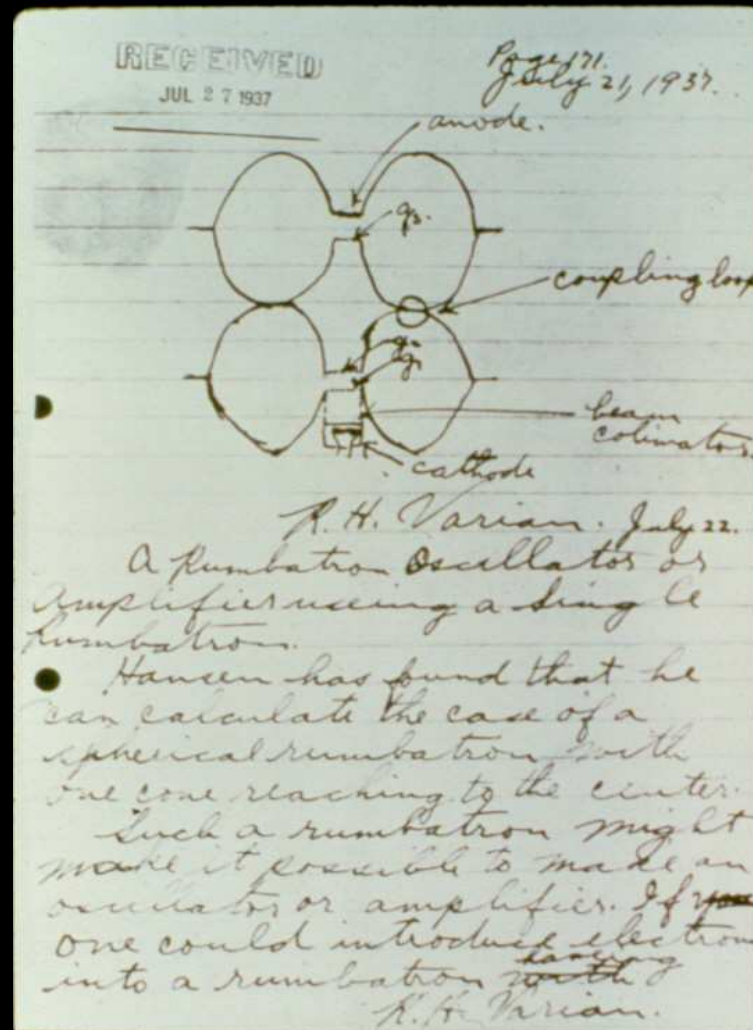
Fig. 14-8. New Memorial Hospital of New York, 1939. Superimposed on the lower right-hand corner is old Memorial hospital.

Memorial Hospital, edificio original 1939

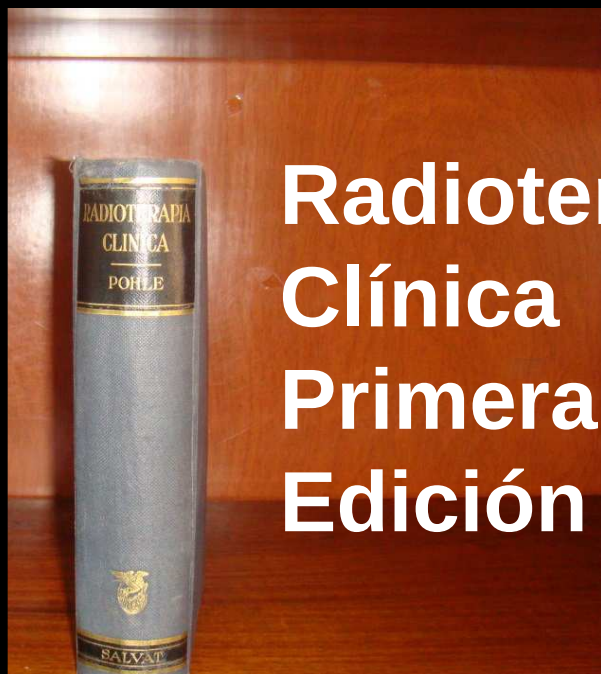


World's first betatron, 1942, 6 mV.
Inventor: Konrad Gund – Erlangen, Germany

1
1942- Primer betatron en uso clínico Konrad Gund



**Entre 1946 y 1950
Hermanos Varian manuscrito. Esto condujo
directamente al diseño del klystron**



Radioterapia Clínica Primera Edición 1955

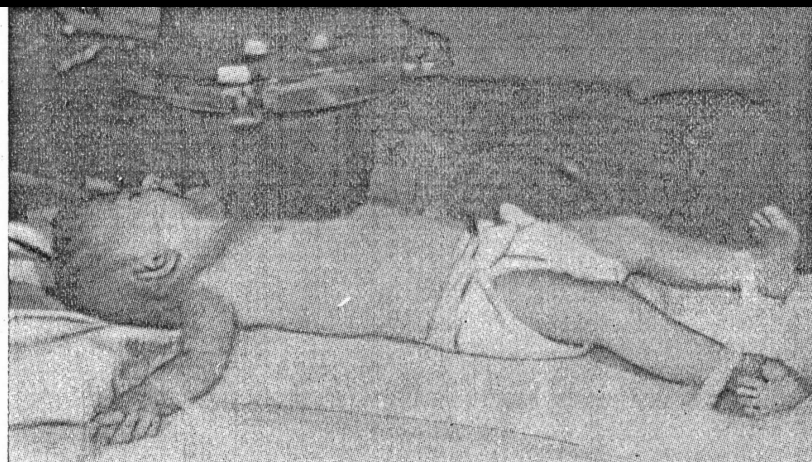


FIG. 139. — Niño sometido al tratamiento Röntgen por timo hipertrofiado. Los brazos y las piernas se han fijado a la mesa con esparadrapo. U mina de caucho emplomado protege el cuello, el pecho y la parte superior del abdomen; lleva un orificio rectangular en su parte central, que corresponde a la zona tímica que debe tratarse. El cono de la figura es grande; puede usarse uno más pequeño, siendo esto cuestión de conveniencia, ya que las partes que no deben tratarse quedan protegidas por el caucho emplomado. (Respecto de la zona que debe irradiarse, véanse las figuras 140 y 141.)

CAPITULO III

LA RADIOTERAPIA EN LAS ENFERMEDADES DEL SISTEMA RESPIRATORIO Y DE LA MAMA

por el doctor GORDON E. RICHARDS

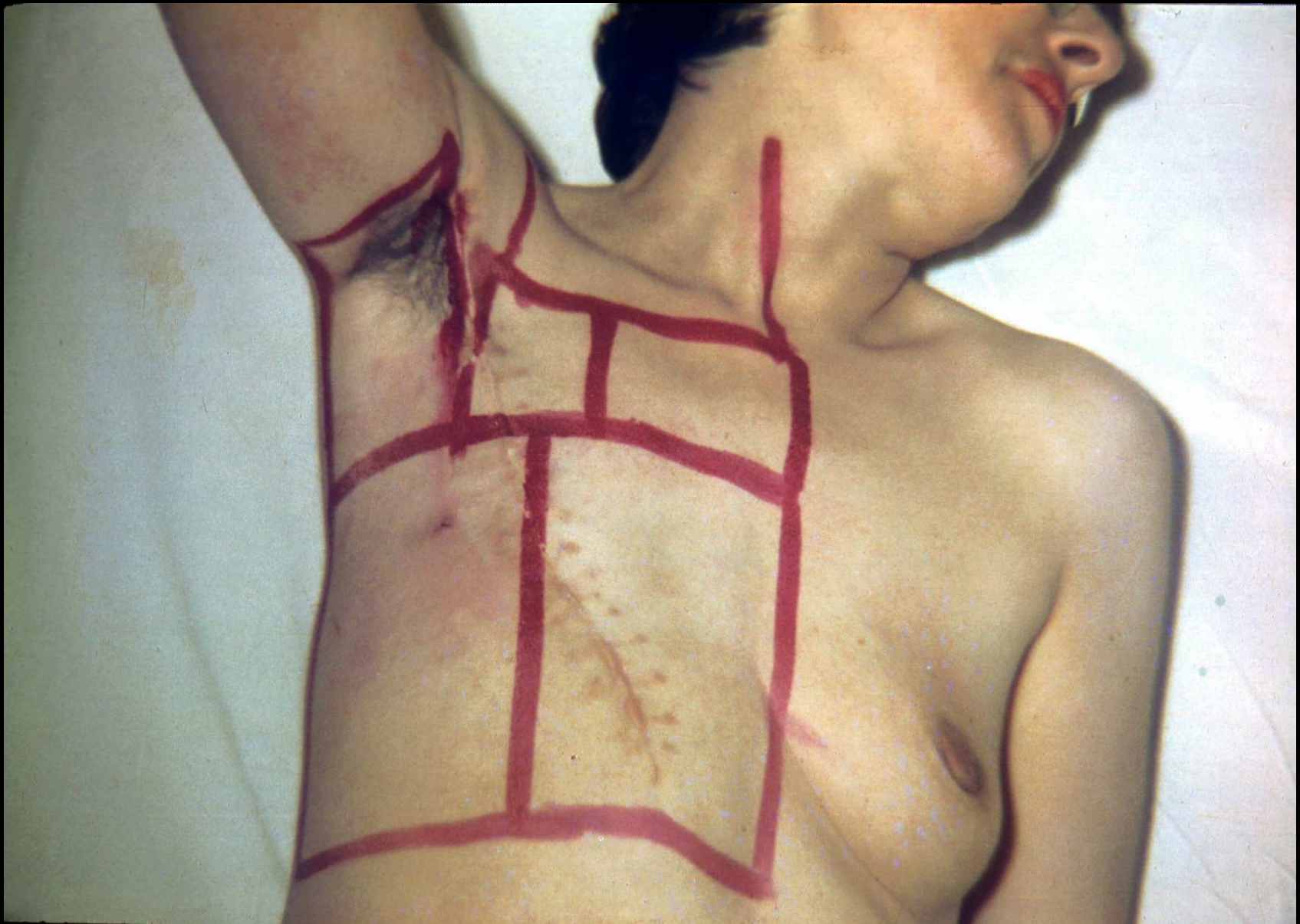
I. Afecciones inflamatorias de las fosas nasales, faringe, pulmones y mama	141
1. Eczema.	141
2. Foliculitis de las fosas nasales.	142
3. Furunculosis.	142
4. Faringitis crónica.	142
5. Sinusitis nasal	144
a) Sinusitis aguda y subaguda	145
b) Sinusitis crónica con hiperplasia	145
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III. Neoplasias malignas de las vías aéreas superiores	162
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e) Otras neoplasias de las amígdalas y de la faringe inferior	169
f) Plan general de tratamiento.	170
g) Técnica del tratamiento de las neoplasias malignas de la amígdala y de la faringe.	171

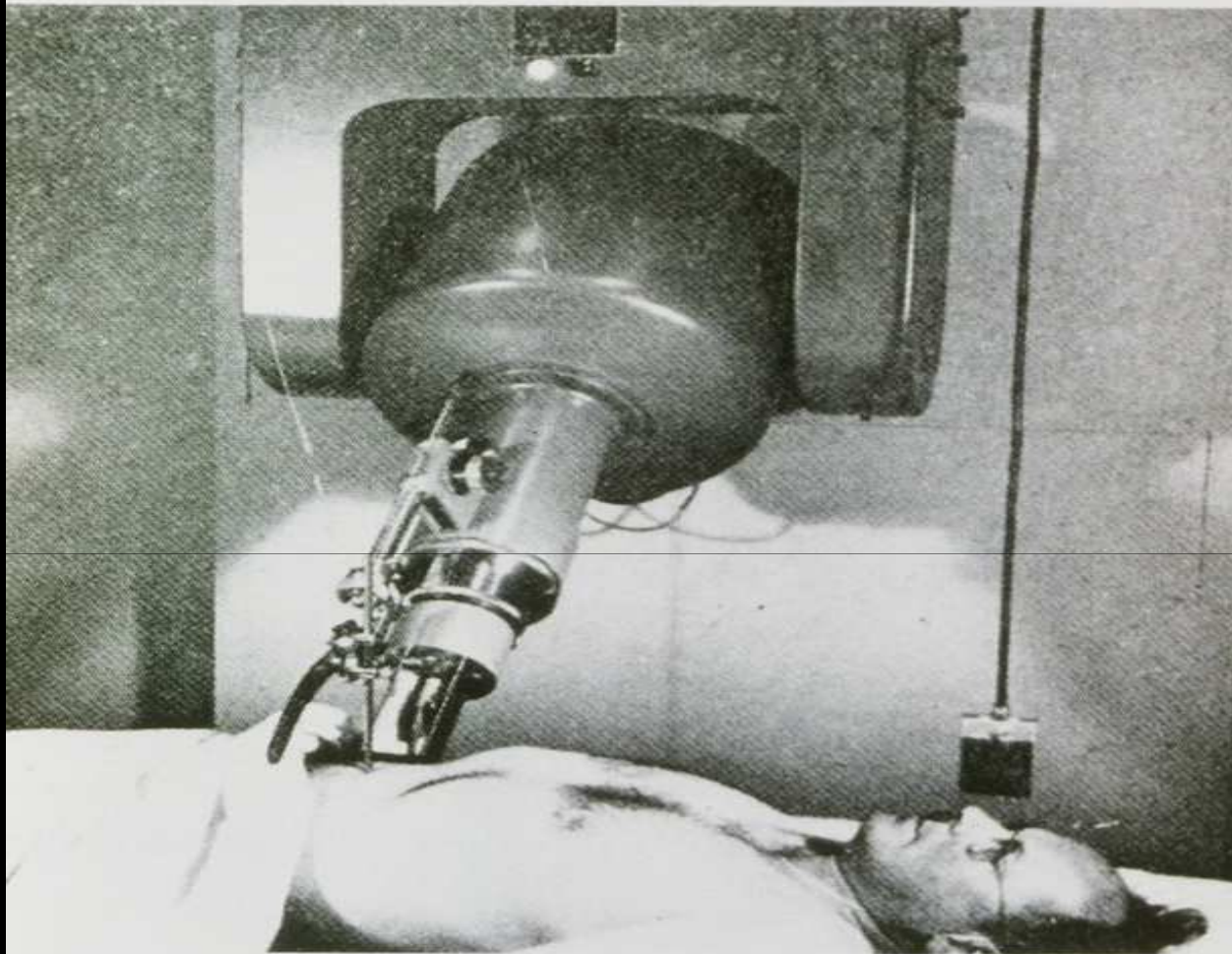
Evolución 1

Desde 1950 a 1970

- ✓ **Radioterapia convencional
1950 a 1970**
- ✓ **Cobalto 60 desde 1951**
- ✓ **Primeros aceleradores
desde 1953**

**1964- “Röntgen bomba” 200 Kv Siemens
Hospital de Clínicas- Córdoba**



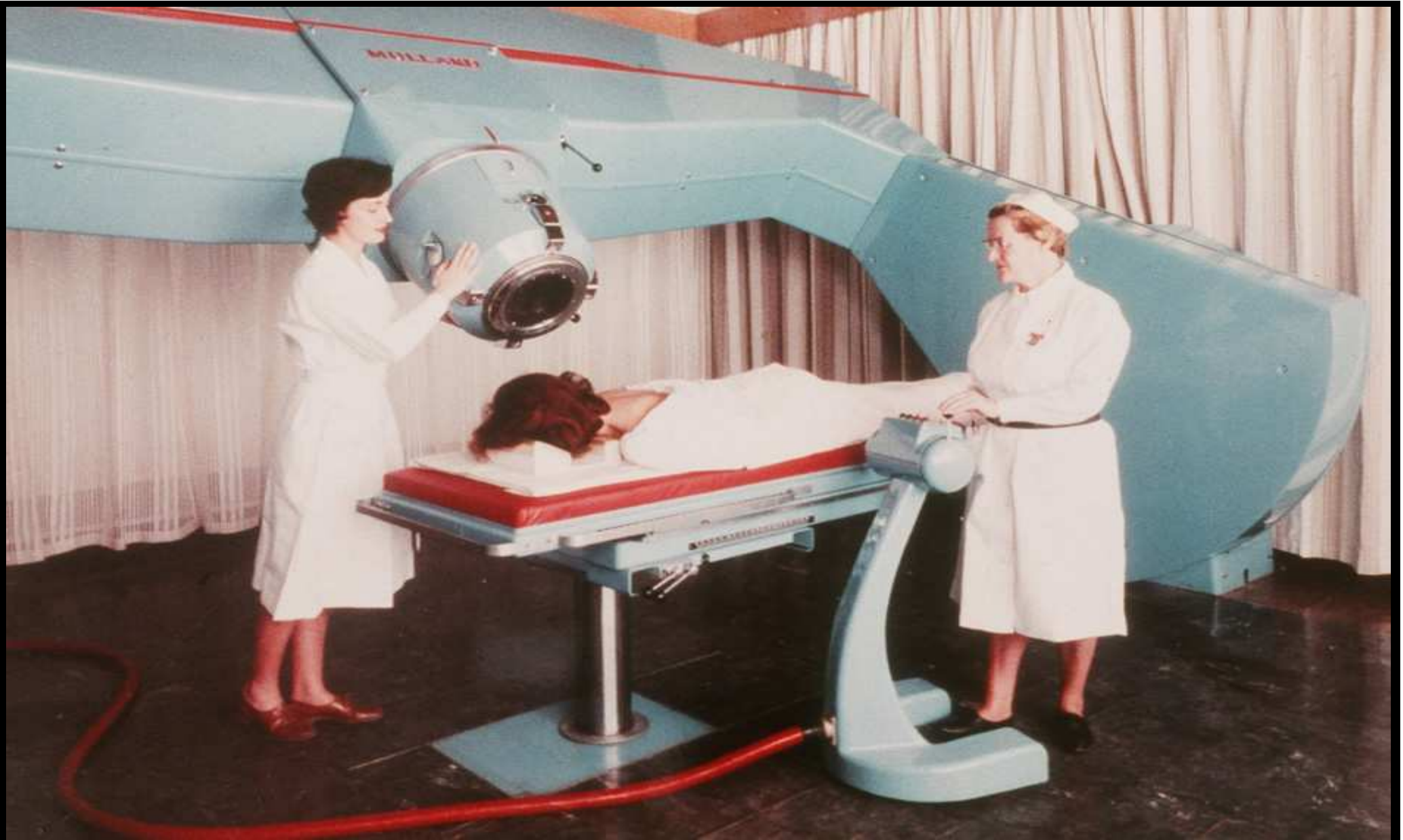


1951
Primera
unidad de
teleterapia
CO⁶⁰

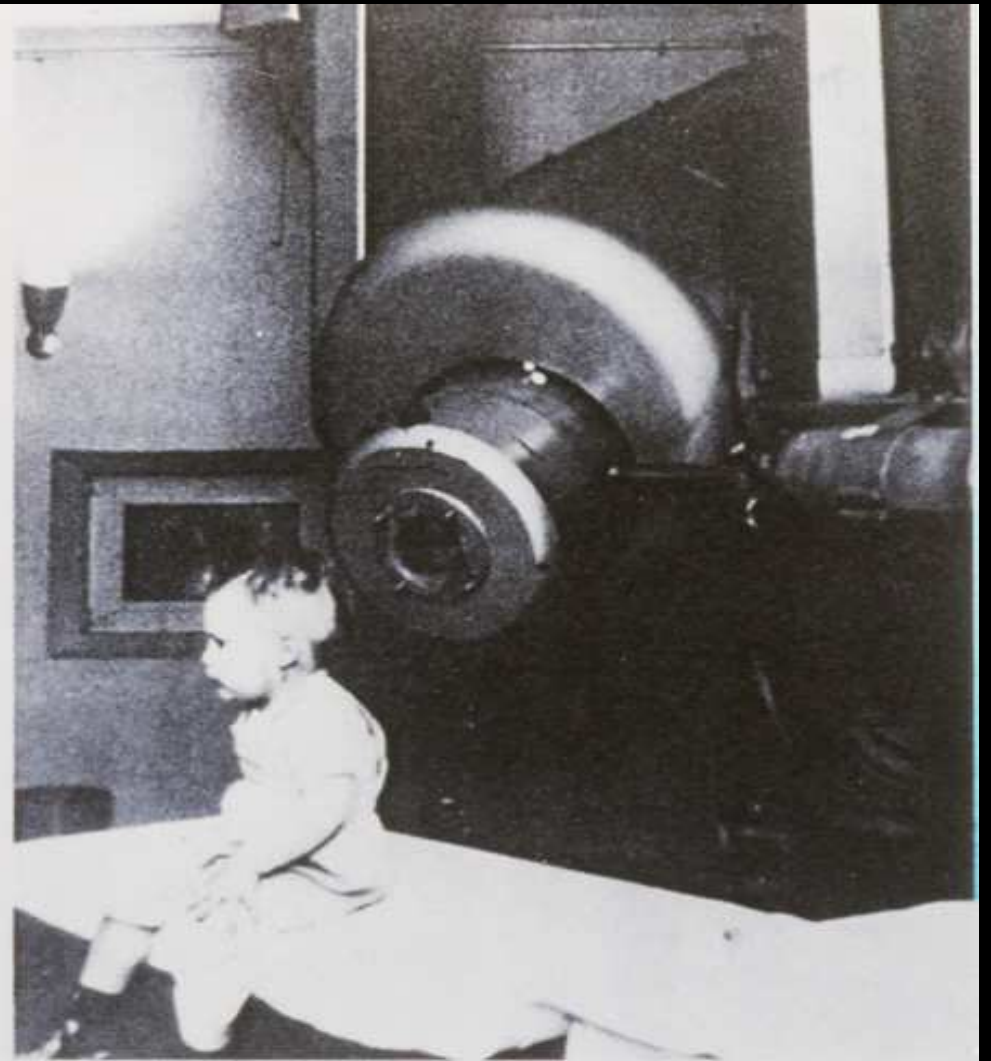
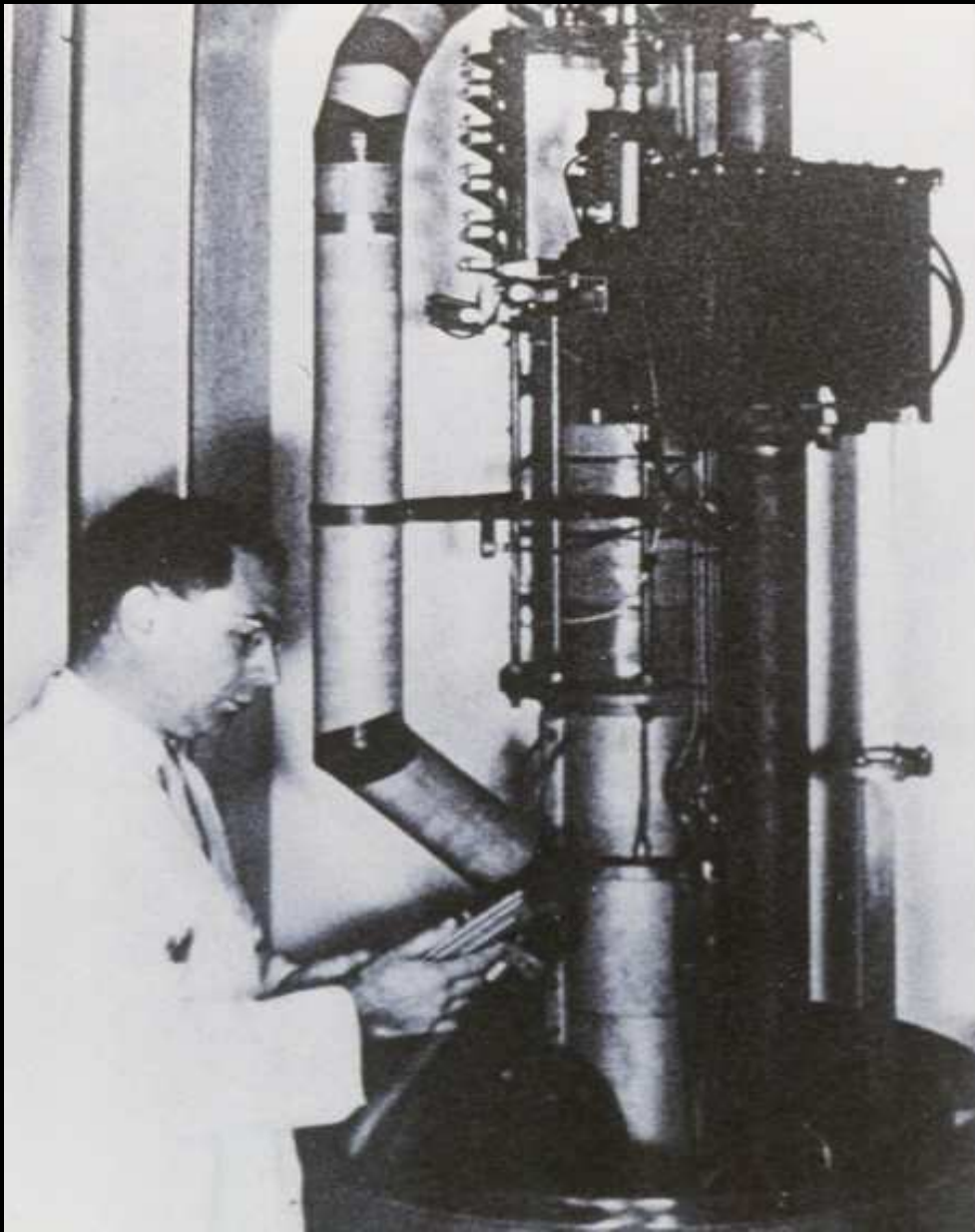
first cobalt-60 radiation therapy unit
(1951).

TABLE 1. Improved Percent of Survival of Several Types of Cancer When Treated With Megavoltage Radiotherapy

Type of cancer	Representative	
	With Kv x-rays (1955)	With MeV x-rays (1970)
Hodgkin's disease	30-35	70-75
Cancer of the cervix	35-45	55-65
Cancer of the prostate	5-15	55-60
Cancer of the nasopharynx	20-25	45-50
Cancer of the bladder	0-5	25-35
Cancer of the ovary	15-20	50-60
Retinoblastoma	30-40	80-85
Seminoma of the testis	65-70	90-95
Embryonal cancer of the testis	20-25	55-70
Cancer of the tonsil	25-30	40-50



1953- Mullard (Philips) 4 MV doble gantry linac



Stanford accelerator with young boy to be treated for retinoblastoma

1956- Henry Kaplan 6 MV Stanford linac 1er. tratamiento



THE FOUR *Rs* OF RADIOBIOLOGY

Now, more than 60 years later, we can account for the efficacy of fractionation based on more relevant radiobiological experiments. We can appeal to the four *Rs* of radiobiology:

Repair of sublethal damage
Reassortment of cells within the cell cycle
Repopulation
Reoxygenation



Eric J. Hall, M.D.

**Basado Regaud's
and Coutard's
work 1920
Instituto del
Radium Paris**

1960 - 1970

Theratron 60 isocéntrica

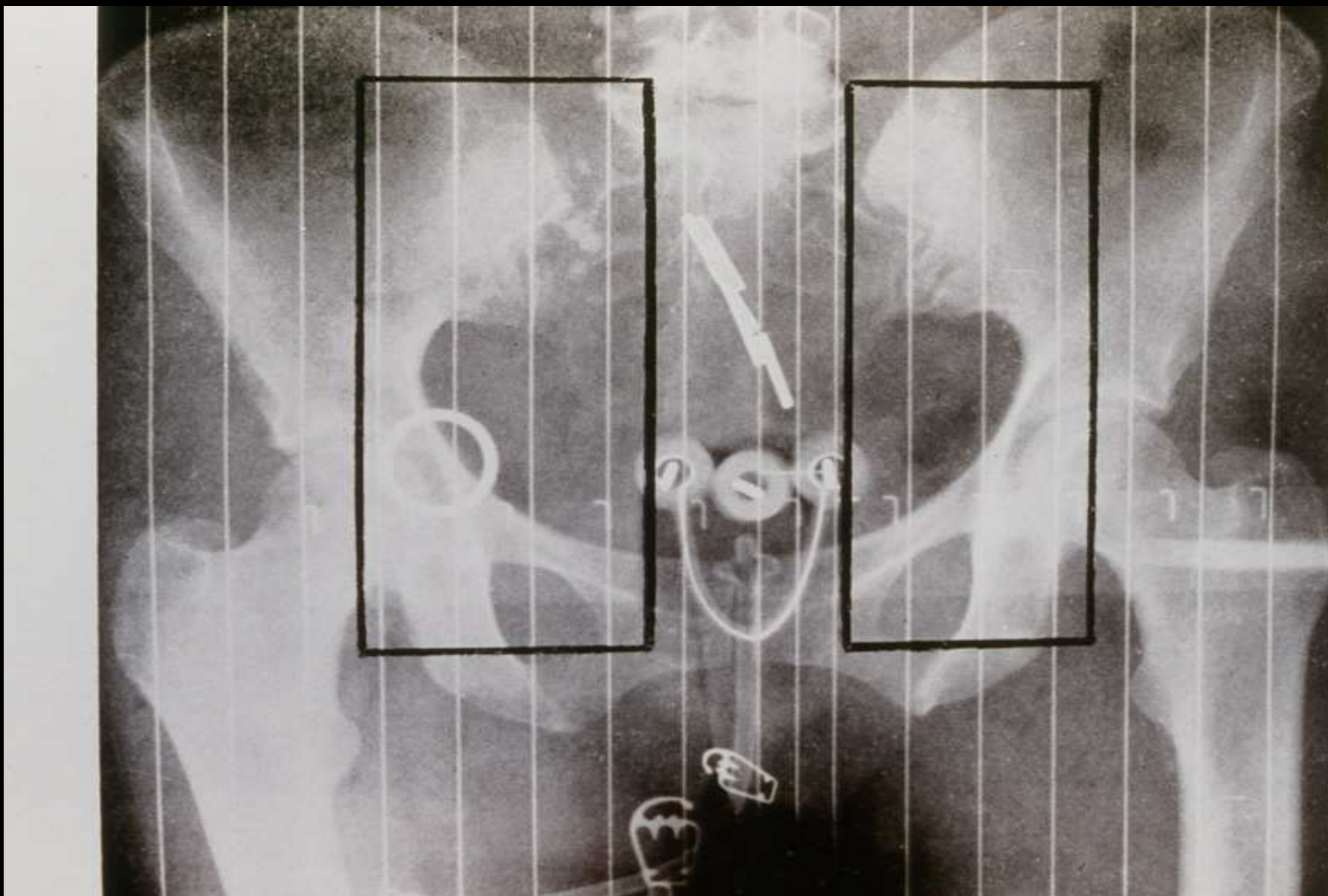


APPLIED RADIATION



Mevatron 8

1966- Siemens Mevatron 8. Dual Fotones



**1962- Simulación con placa radiográfica
Cobalto más ovoides de Manchester**

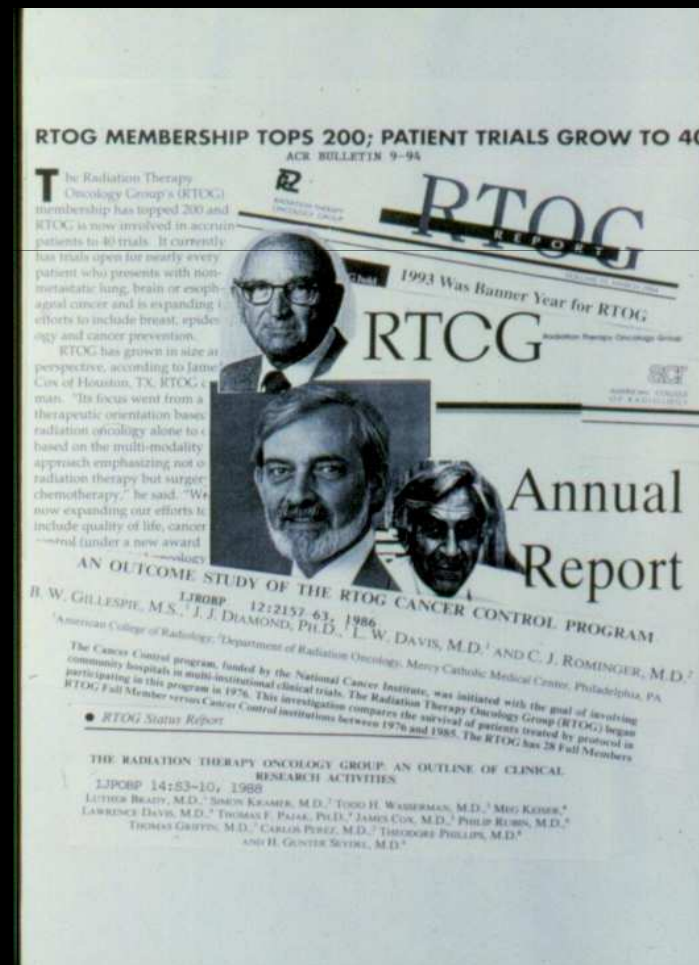
Organizaciones para la Investigación

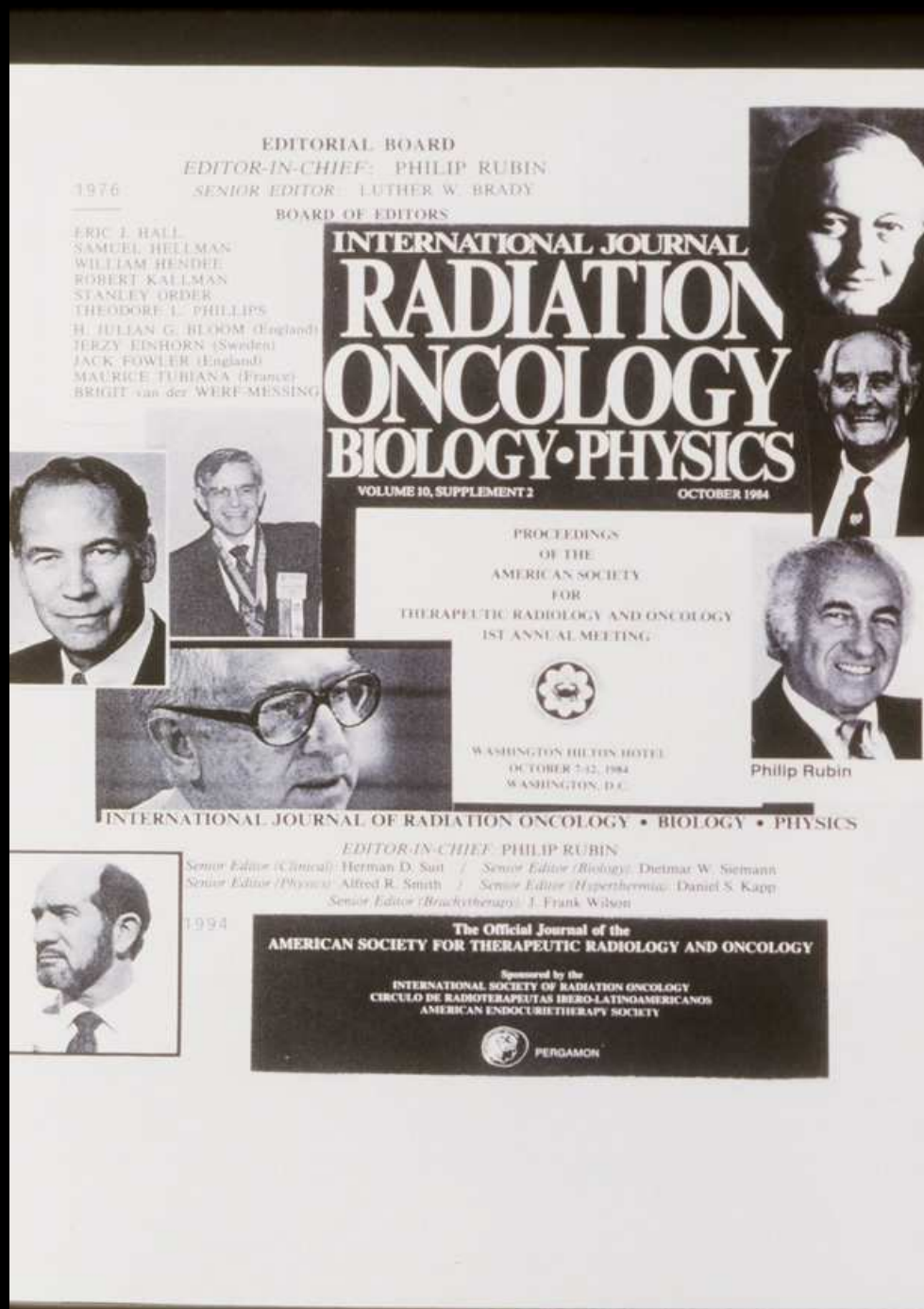
1962 EORTC

(European Organisation for Research and Treatment of Cancer)

1968 RTOG

(Radiation Therapy Oncology Group)



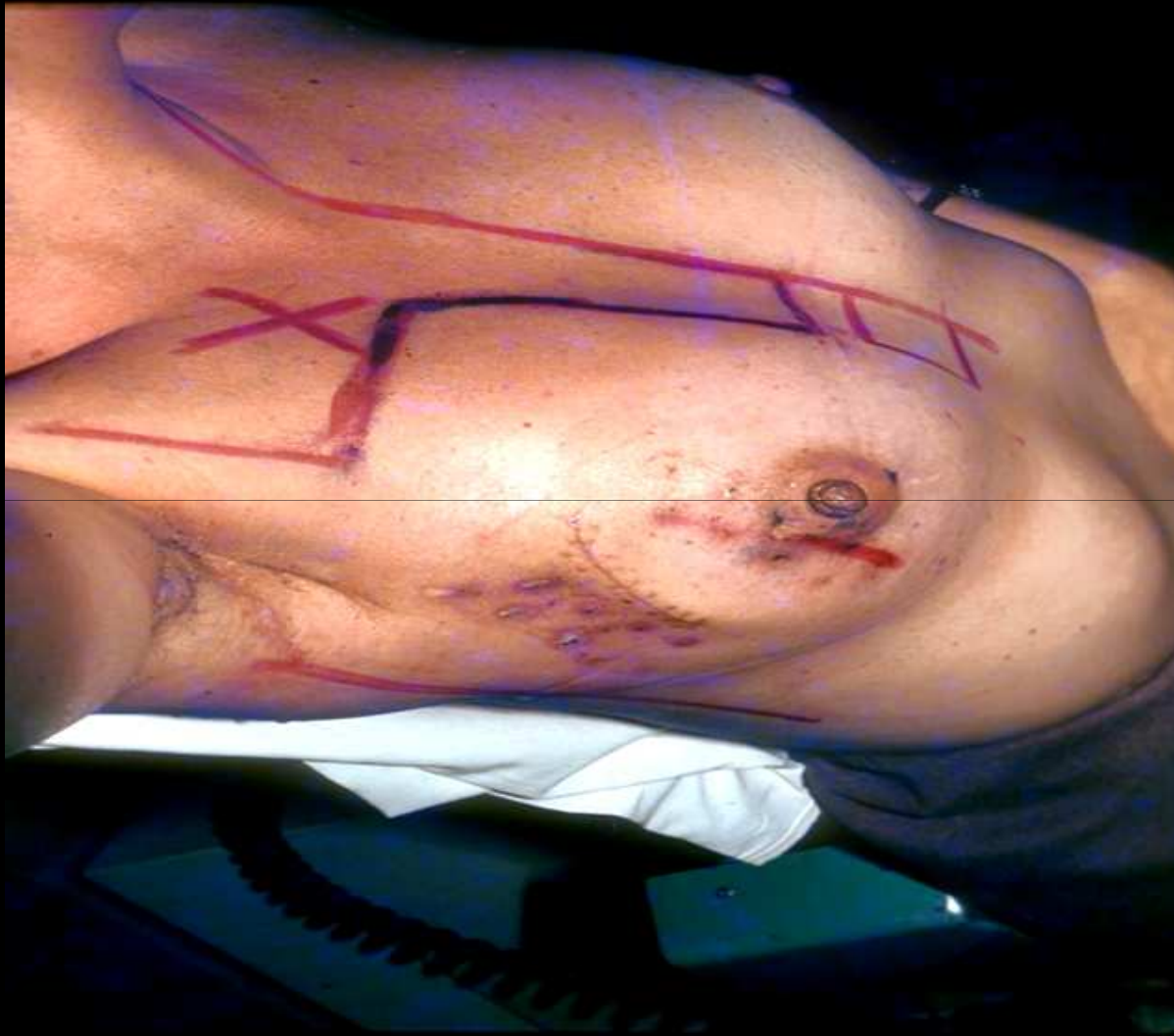


1976 1ra. Edición
Iniciativa de
Philip Rubin y
Luther Brady

1970 - 1980 Theratron 80



1970's - 1980's



Riesgo supera Beneficios

**Toxicidad
a > 15 años**

Cuzick 1987

Radioterapia postmastectomia

Mayor mortalidad por causa

NO cáncer en pacientes

irradiadas vs no irradiadas

QUALITY ASSURANCE IN RADIATION THERAPY: Clinical and Physical Aspects

Proceedings of the First International Symposium
on Quality Assessment in Radiation Oncology

Washington, D.C.
8-10 June 1983

Gerald E. Hanks, M.D.
Chairman



Published as a supplement to the
INTERNATIONAL JOURNAL OF
RADIATION ONCOLOGY/BIOLOGY/PHYSICS

1983
Programas de
Garantía de
Calidad

Evolución 2

- ☐ **Aceleradores lineales de mayor precisión y seguridad. Altas energías de fotones y electrones**
- ☐ **Desarrollo de simulación 2D primero con equipos de Rayos x después simuladores**
- ☐ **Radiografía verificadora**
- ☐ **Accesorios para inmovilización**

Clinac 2500C

- 1.9 M, SW, Switched Accelerator
- Advanced Dual Plane, 270° Achromatic Bending Magnet
- Dual X-Ray Energies, 6 and 24 MV
- Extended Range Electrons, 6-22 MeV
- 5.5 MW Klystron
- Advanced Control System
- Standard Independent Collimation, Special Procedures and RV Features
- Designed to Provide the Most Advanced Treatment Capabilities Now, and to the Year 2000



1990s

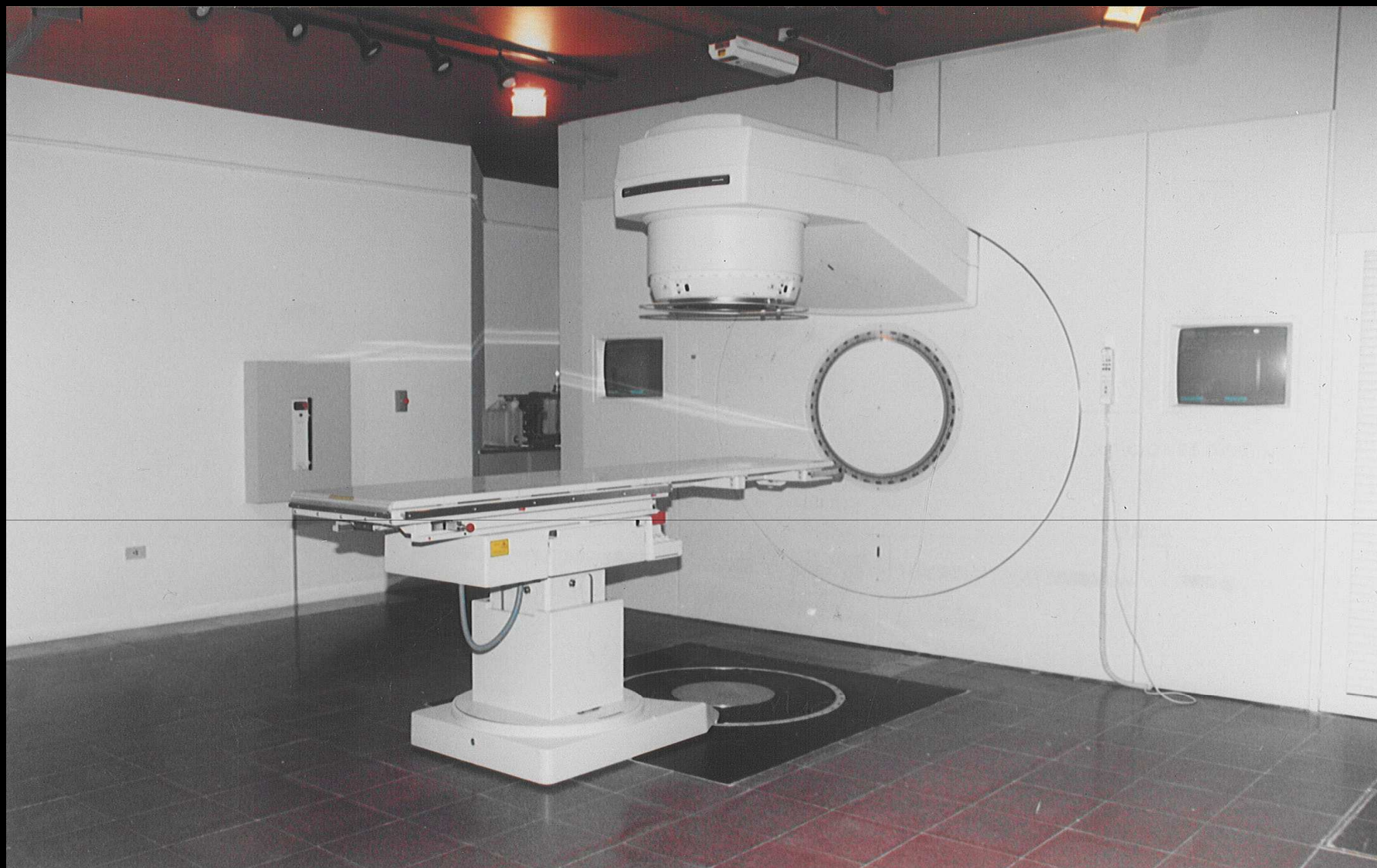
Preocupación por la formación de Recursos Humanos para el manejo de radiaciones ionizantes

Fundación Marie Curie 1988



Formación de Recursos Humanos
Radioncólogos 12 (1985-2009)
Físicos Médicos 14 (1980-2009)
Técnicos Radioterapeutas 30
Médicos Visitantes 30

Oncólogos Clínicos 35 (1989-2009)
Posgrado compartido con Servicio de
Oncohematología – Hospital Privado

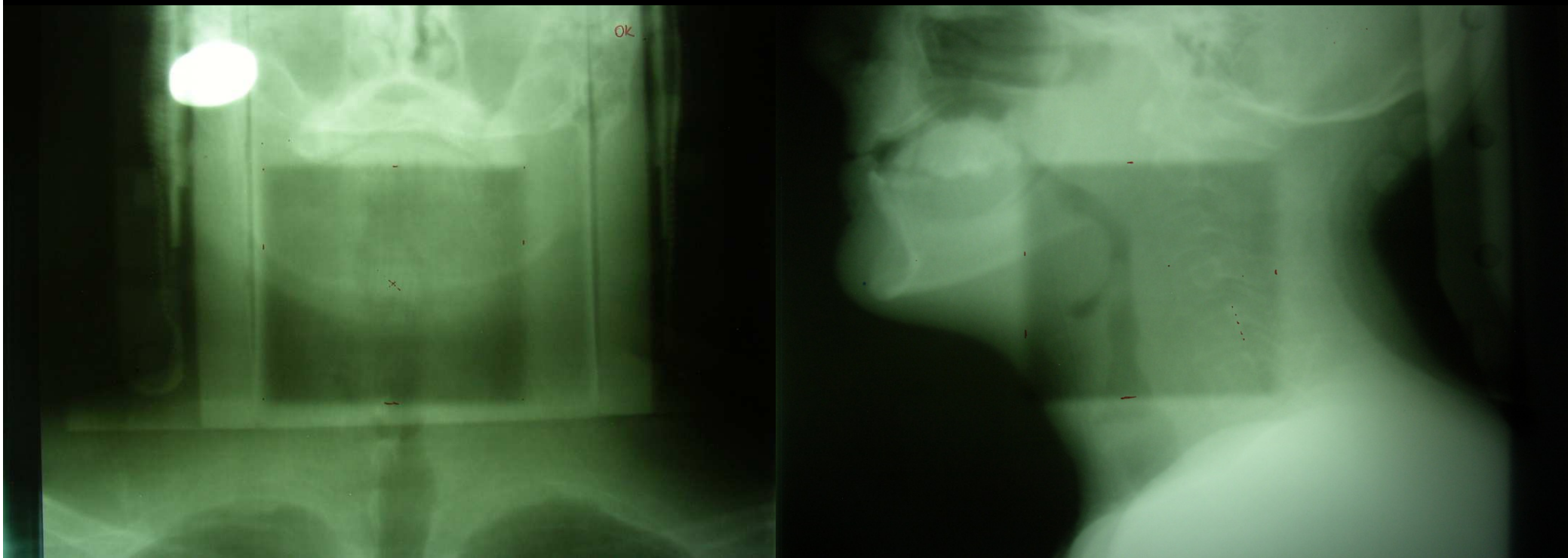


1990 a 93- Serie SL 15 Philips

Simulador Ximatron 5 Varian



Verificadoras, placa radiográfica Kodak oncológica



TAC Breve historia

1970's cambió el curso de la imagenología mundial cuando el primer dispositivo de TAC fue puesto en operación clínica por el científico británico G. N. Hounsfield Premio Nobel de Fisiología en 1979

1973 Se instaló el primer TAC cerebral en la Clínica Mayo

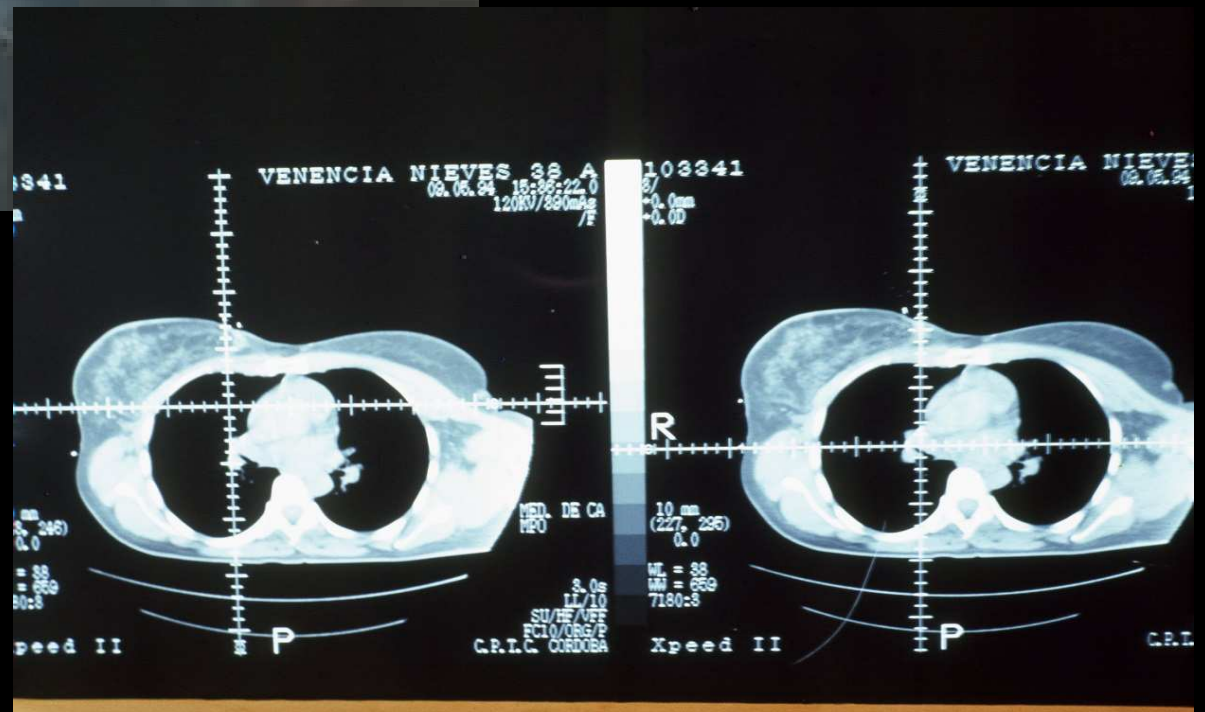
Influencia de las imágenes

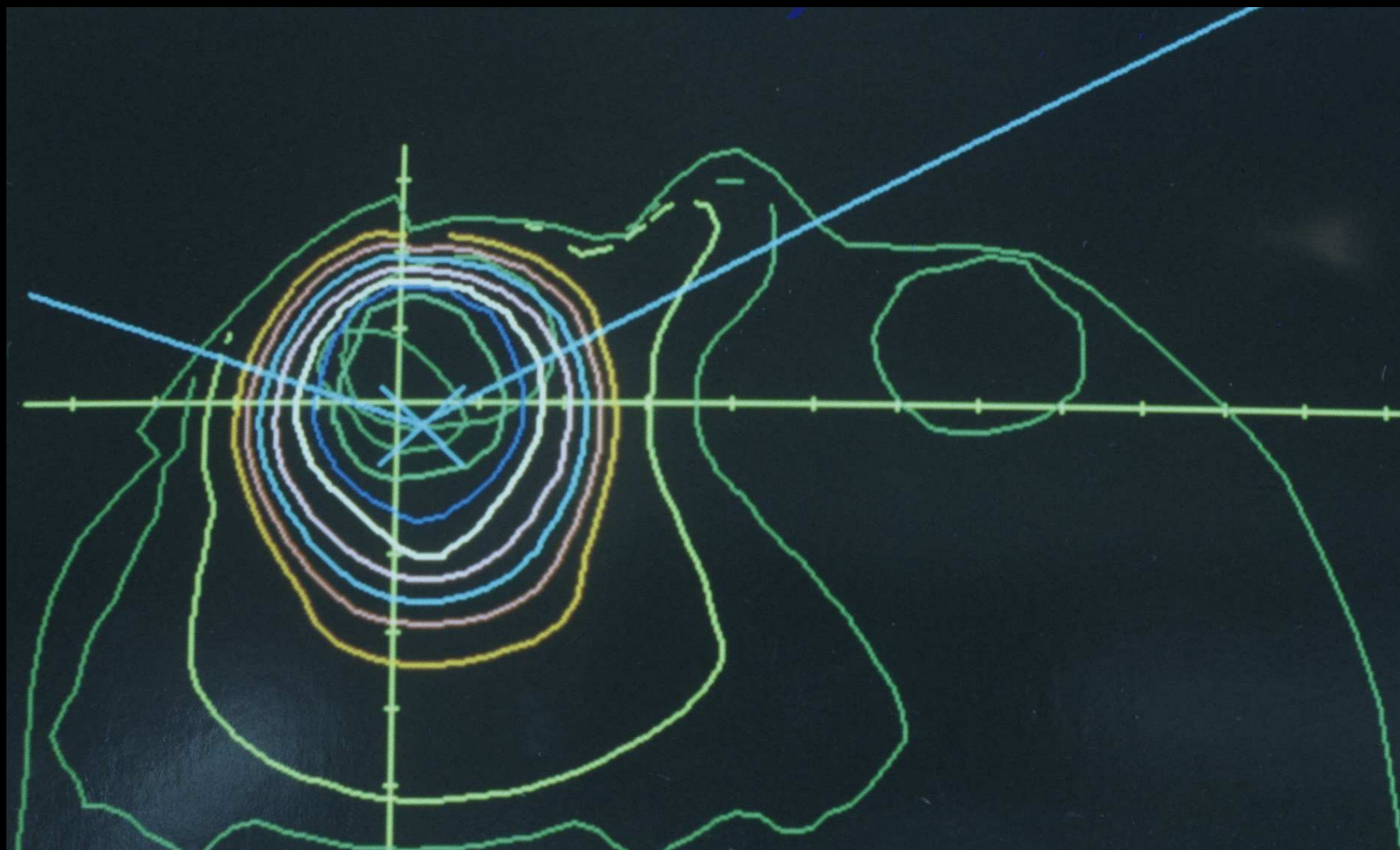
**Tomografía computada provocó
un cambio de concepto en la
forma de entregar radioterapia
de 2D a 3D**

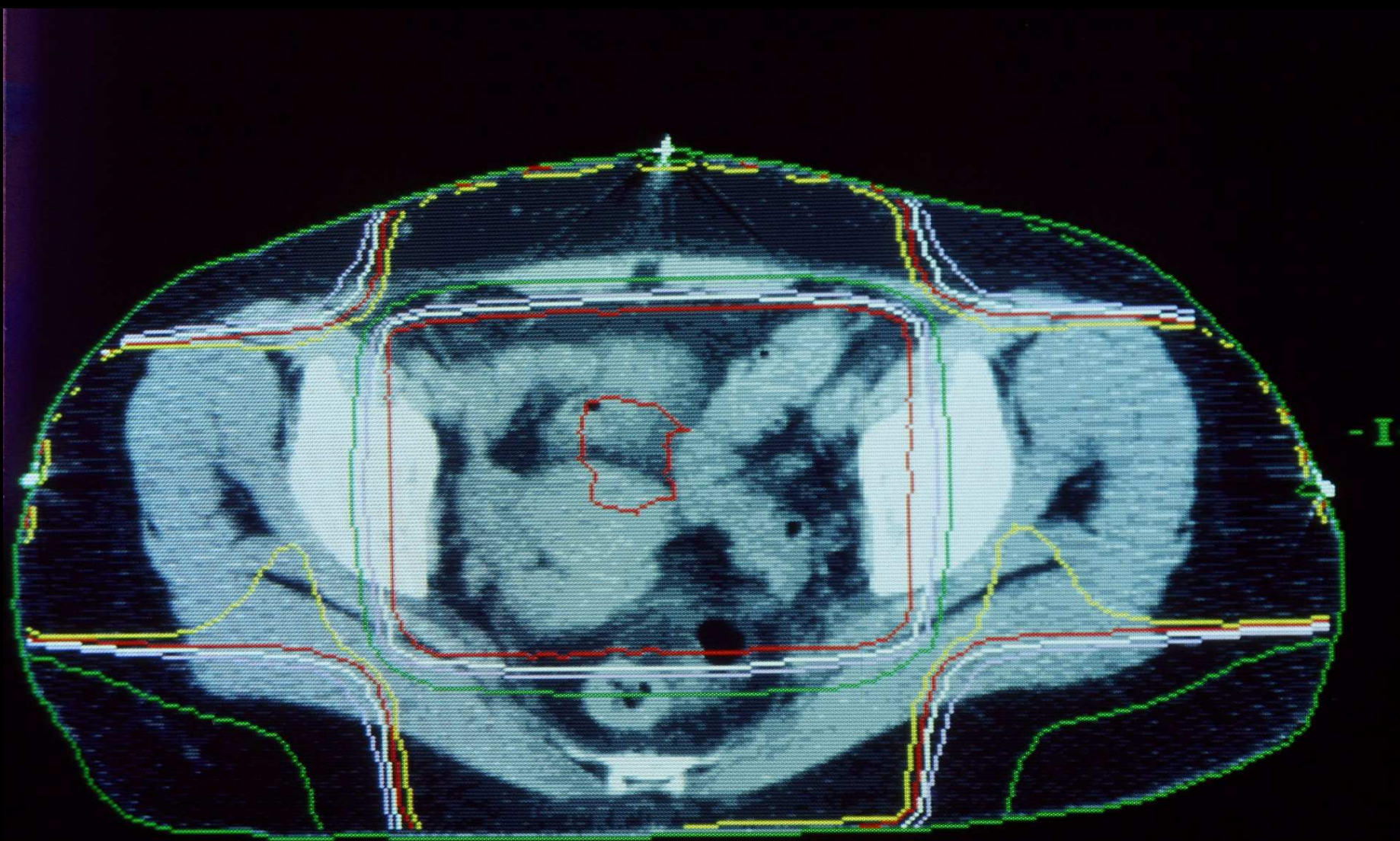


Planificación 2D

+ algunos cortes
tomográficos
= 2.5 D



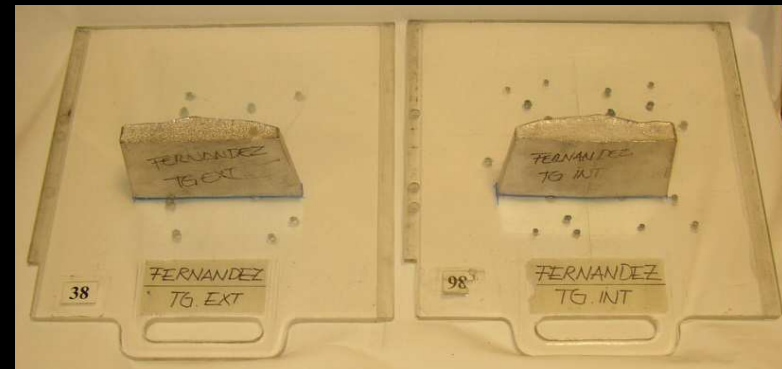
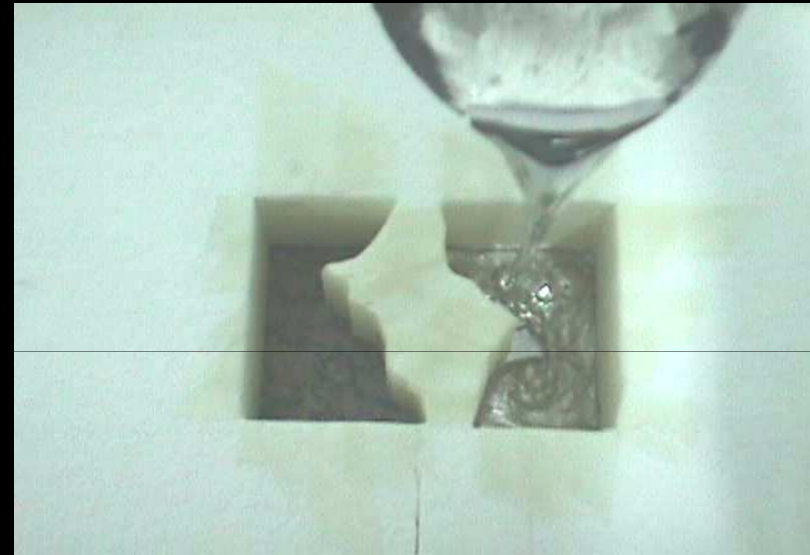
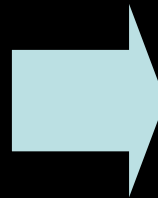


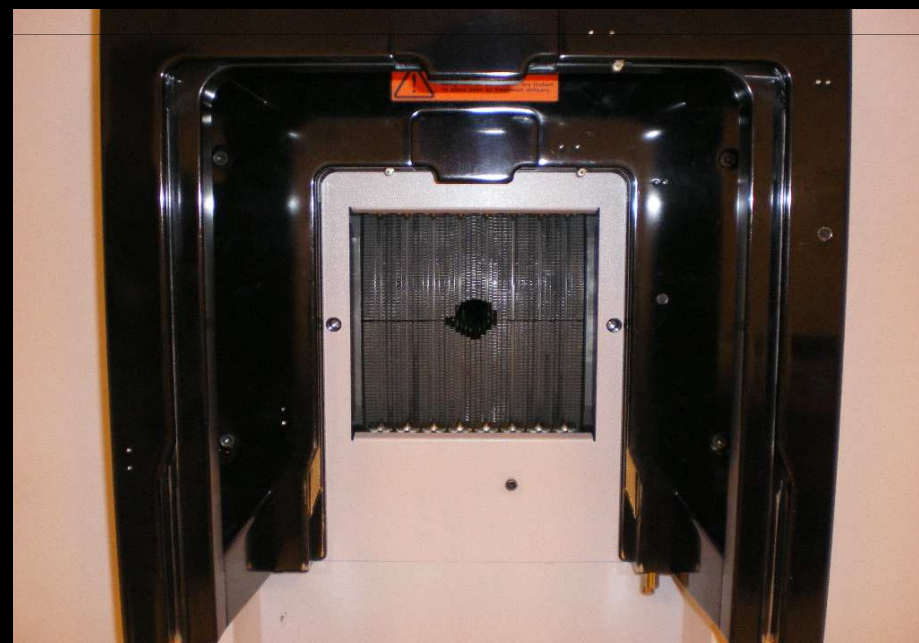
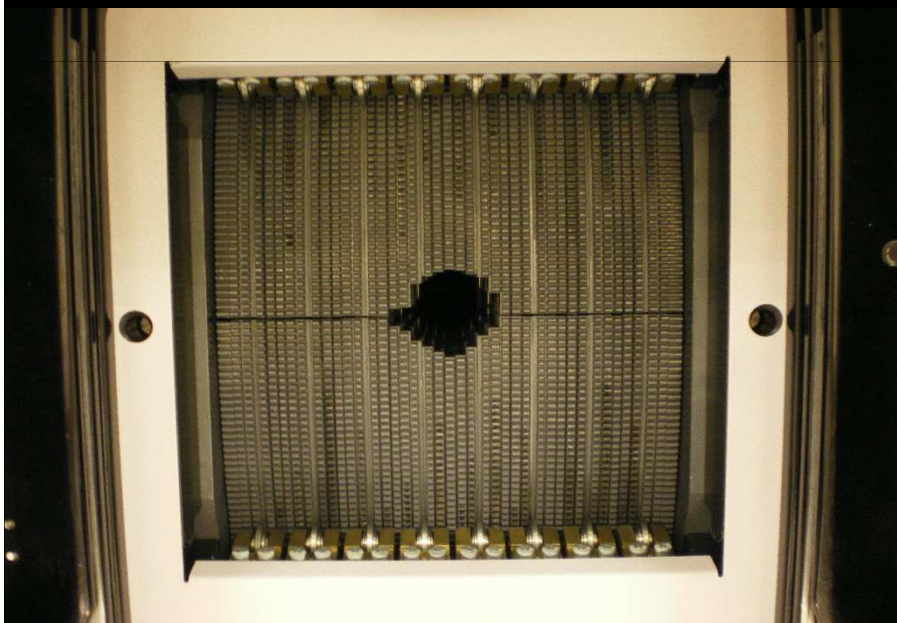
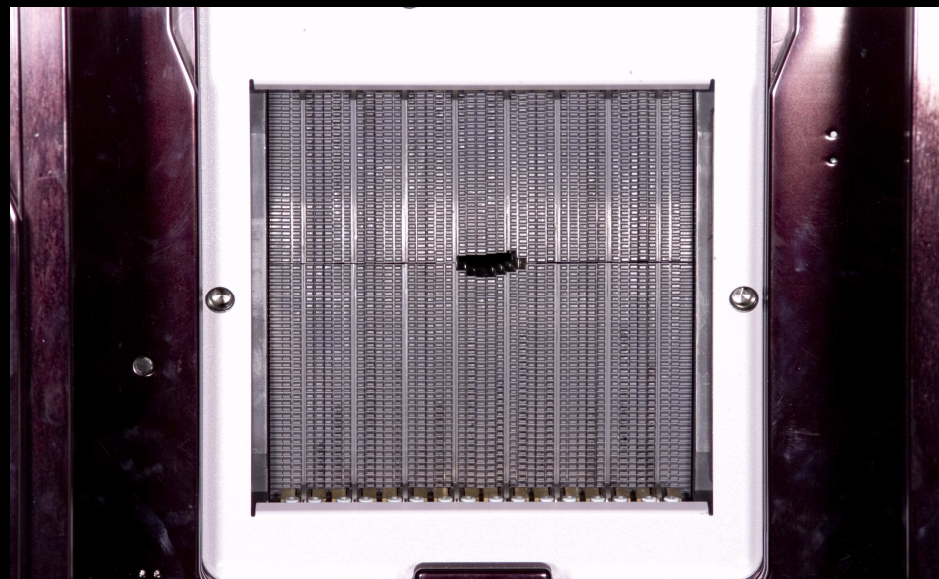
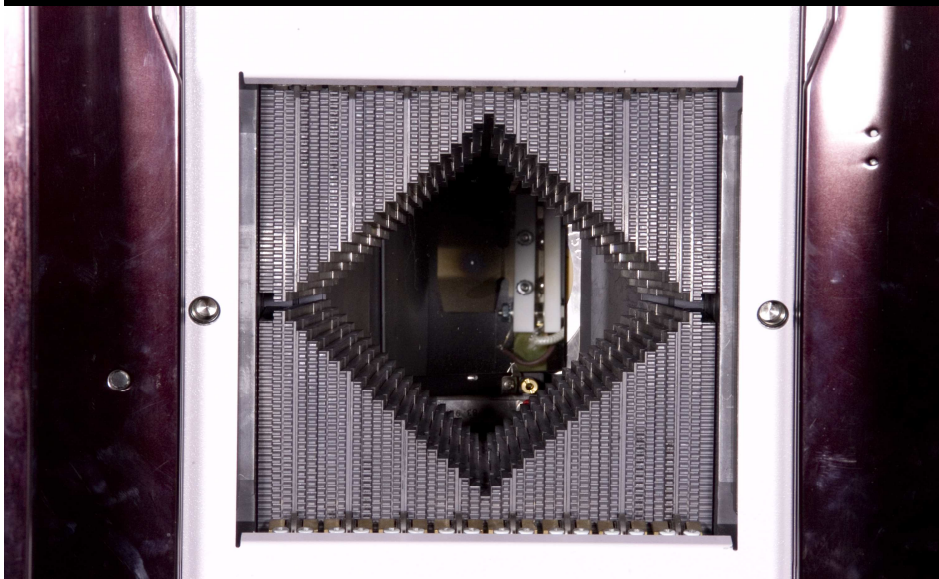




Planificación de 2D a 3D

Construcción de Protecciones Conformadas





MLC (Colimador Multihojas)



**Tomógrafo axial computado
helicoidal dedicado a RT
Somaton Siemens**



Simulación virtual

CT simulator



Atención Dra. Améndola

FOCUS
Into the Future
VAX-Based Treatment Planning Therpa
 ONCOLOGY SYSTEMS
 by Pinecliff Associates

POTENTIAL FOR IMPROVEMENT IN RADIATION THERAPY
 [JROBP 14:777 (1988)]
 HERMAN D. SUIT, M.D., D.PHIL.,* JAMES BECHT, M.D., JOSEPH LEONG, PH.D.,
 MICHAEL STRACHER, B.Sc., WILLIAM C. WOOD, M.D.,† LYNN VERHEY, PH.D.,
 AND MICHAEL GOITEIN, PH.D.

SCANDIPLAN
 3-DIMENSIONAL RADIATION THERAPY
 TREATMENT PLANNING SYSTEM

PROWESS
 2000
 PLANNING SYSTEM

ROCS
 Radiation Oncology Computer Systems, Inc.

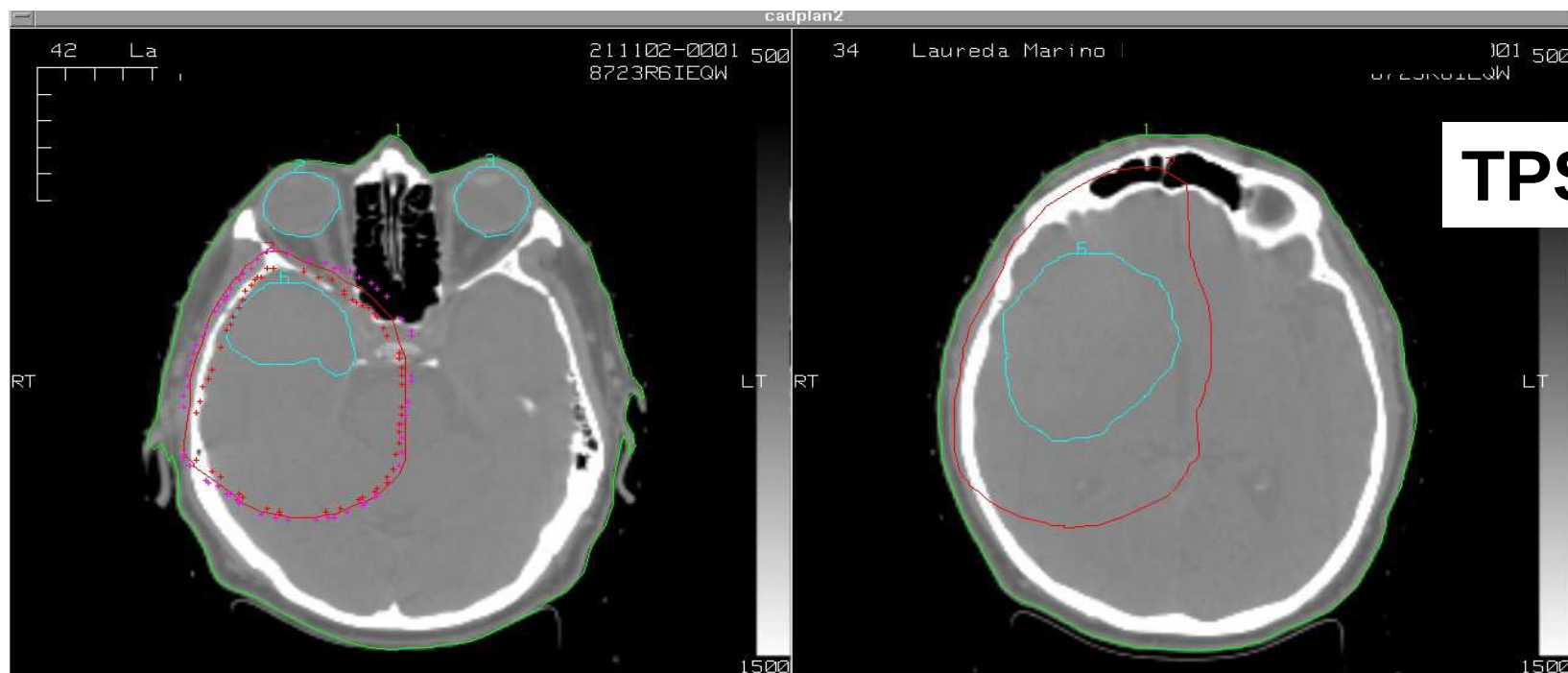
RENDER PLAN 3-D
 CLINICALLY PROVEN AND AVAILABLE NOW
 FROM PRECISION THERAPY

rapid with port verification

Difusión de los planificadores de tratamiento



PCRT 3D



TPS CadPLAN

CadPlan2 Contouring Workspace

File Edit View Workspace Volume Tools Help

Contours Volume Image View Patient AutoContour

Slice 42

- 1 BODY
- 2 Ojo Der
- 3 Ojo Izq
- 4 glandula lag
- 5
- 6 GTV
- 7 PTV
- 8
- 9
- 10

Image No. 42 Reference Image No. 34

Plane	Coord.	No.
Z	-3.70	37
Z	-4.00	38
Z	-4.20	39
Z	-4.50	40
Z	-4.70	41
Z	-5.00	42
Z	-5.20	43

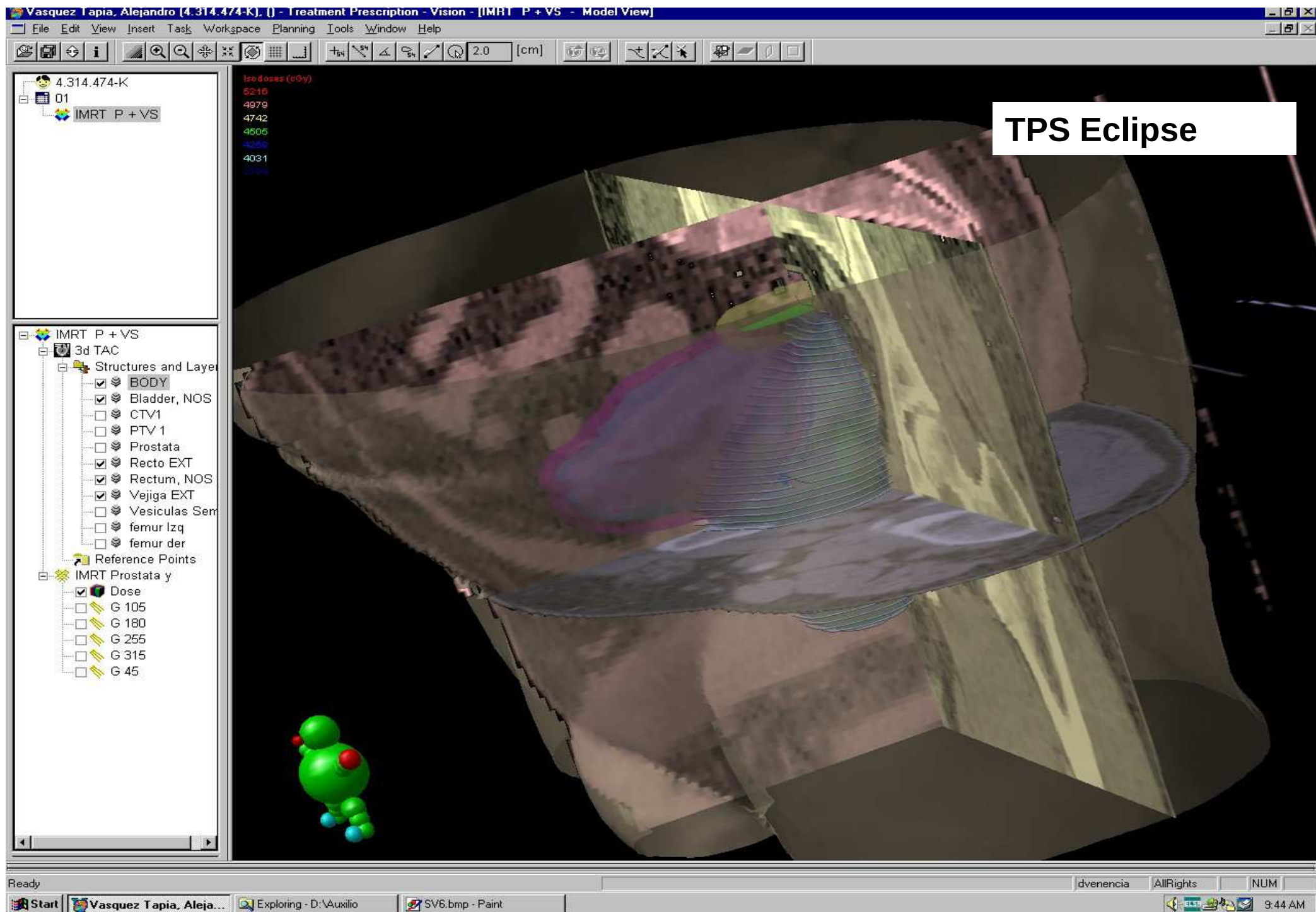
Plane	Coord.	No.
Z	-2.20	31
Z	-2.50	32
Z	-2.70	33
Z	-3.00	34
Z	-3.20	35
Z	-3.50	36
Z	-3.70	37
Z	-4.00	38

Source Volumes

No.	Volume Label:
1	BODY
2	Ojo Der
3	Ojo Izq
4	glandula lag
6	GTV
7	PTV

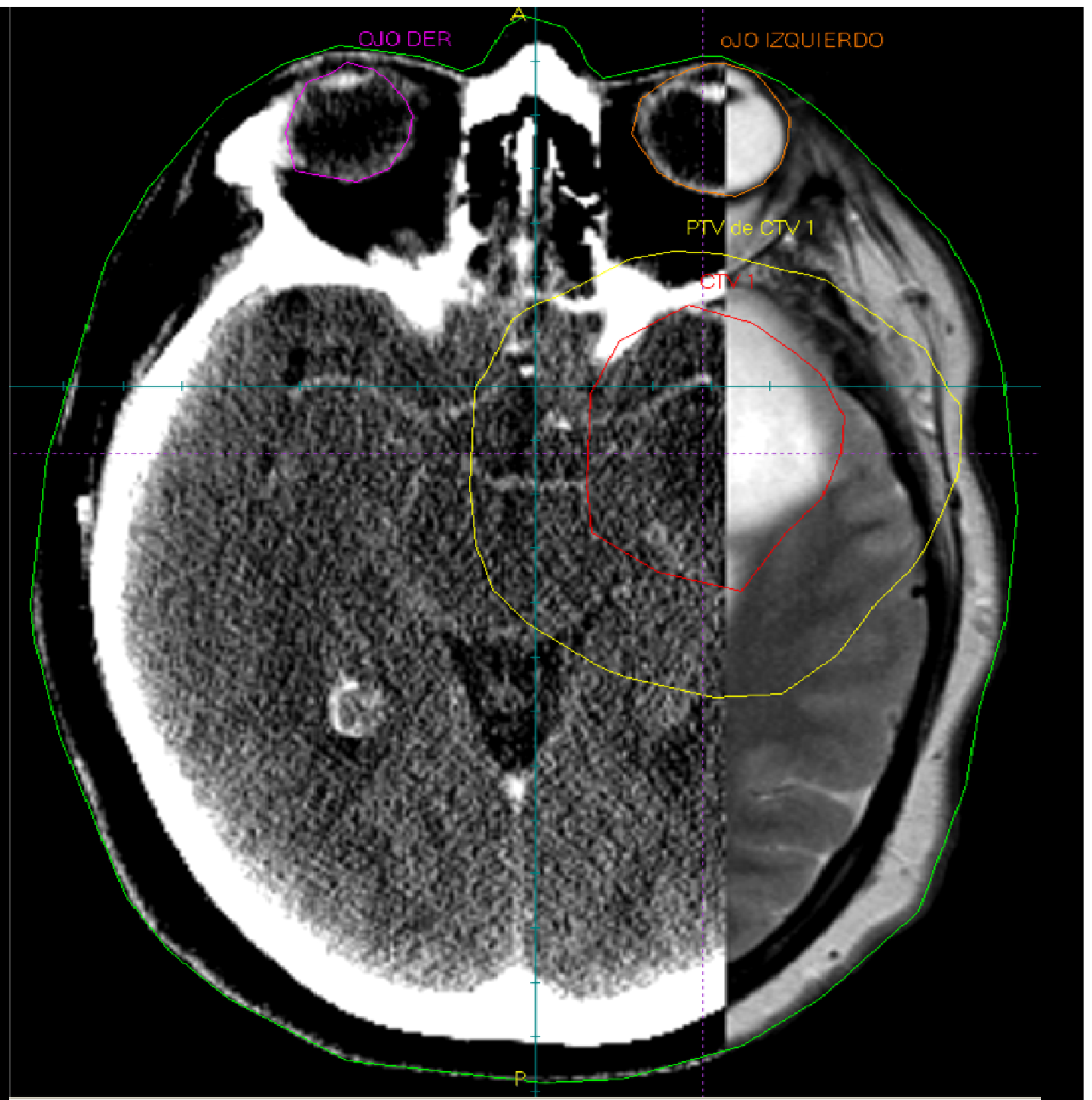
Delete Volume Edit



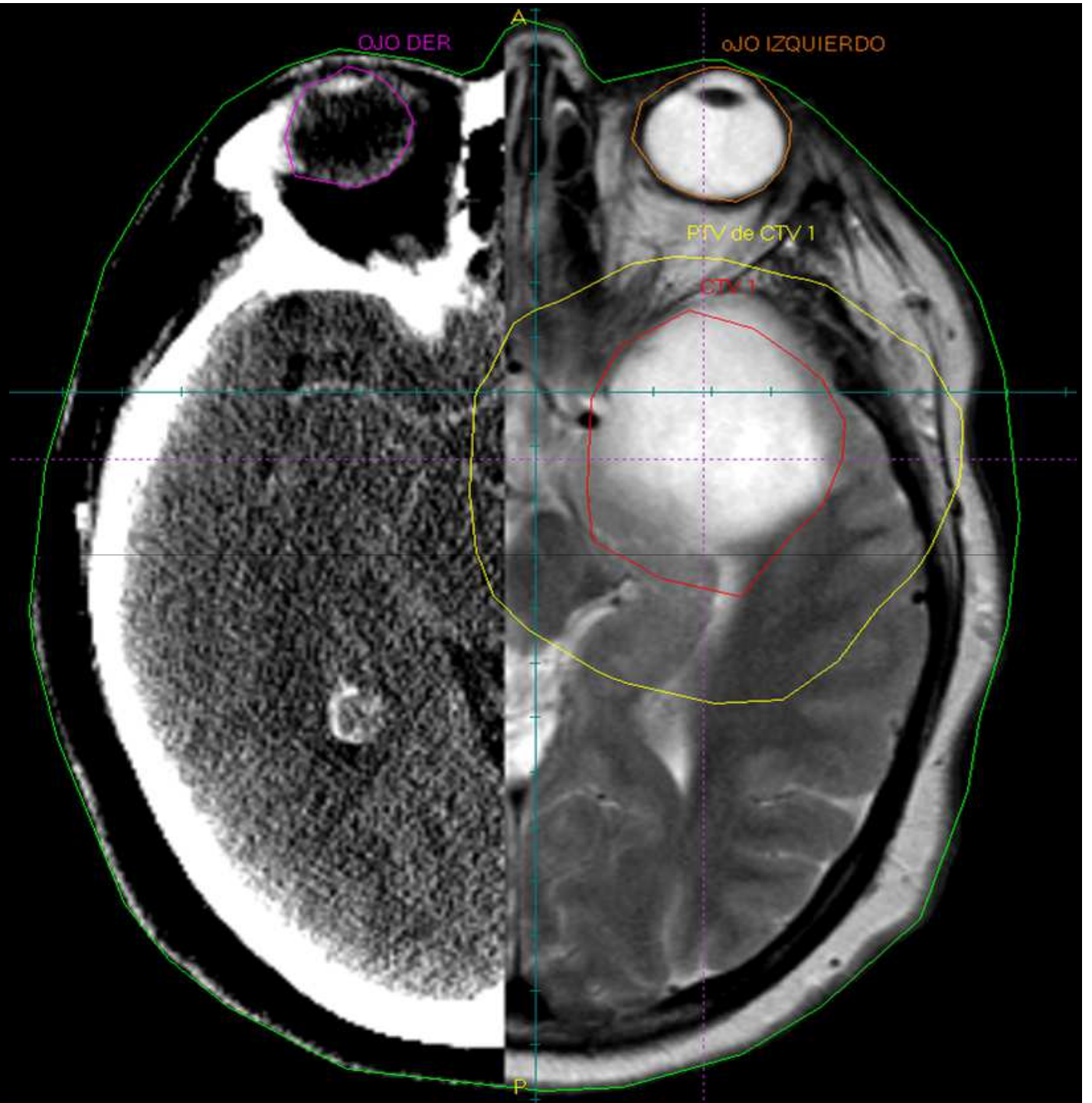


**Soporte de RM y PET
para mejorar la entrega
de radioterapia**

Fusión de imágenes

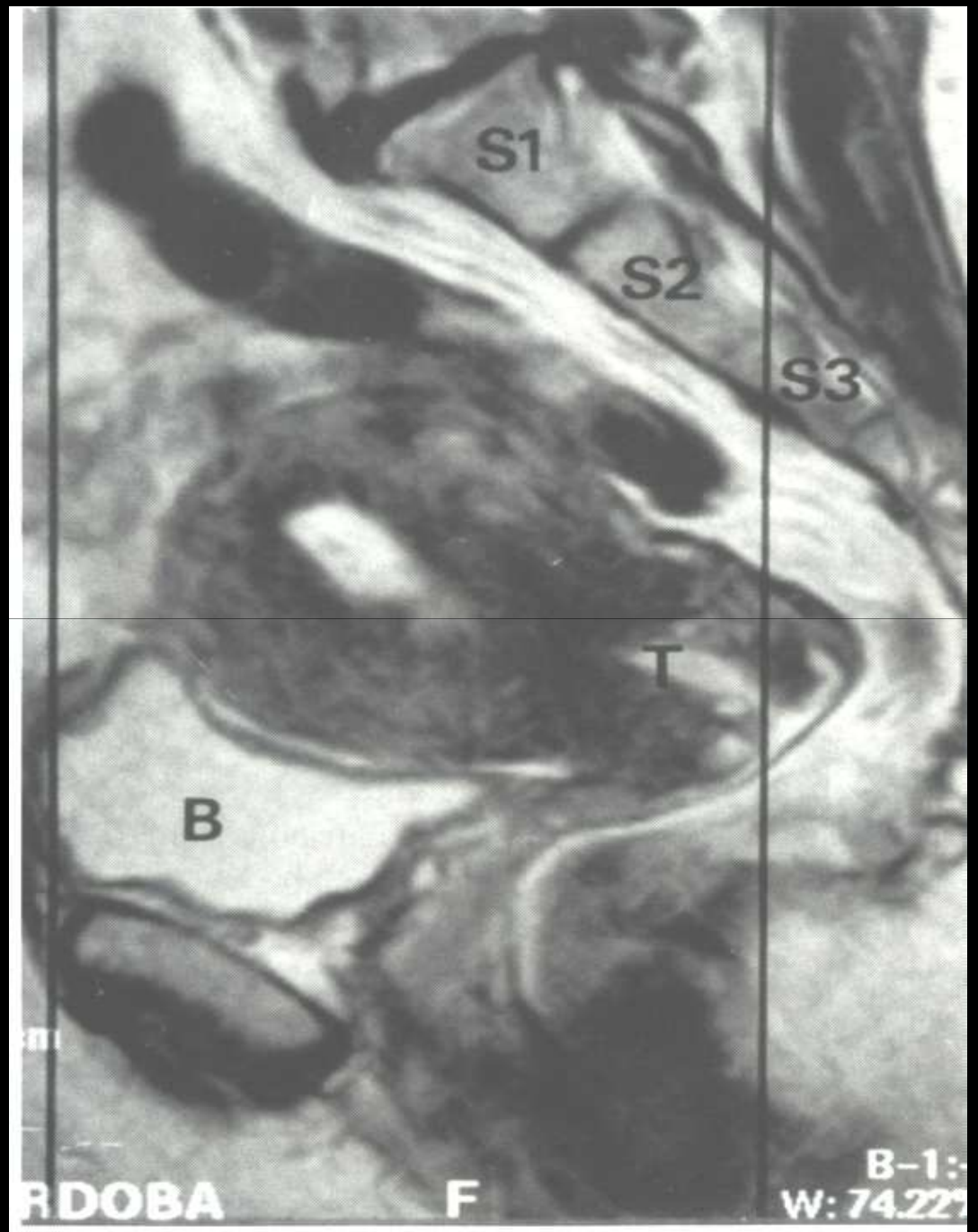


Fusión de imágenes

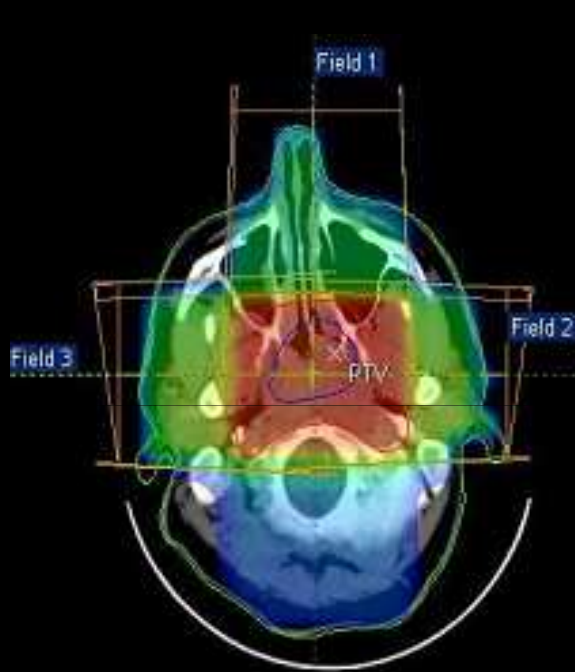


Influencia de RM en la técnica de box

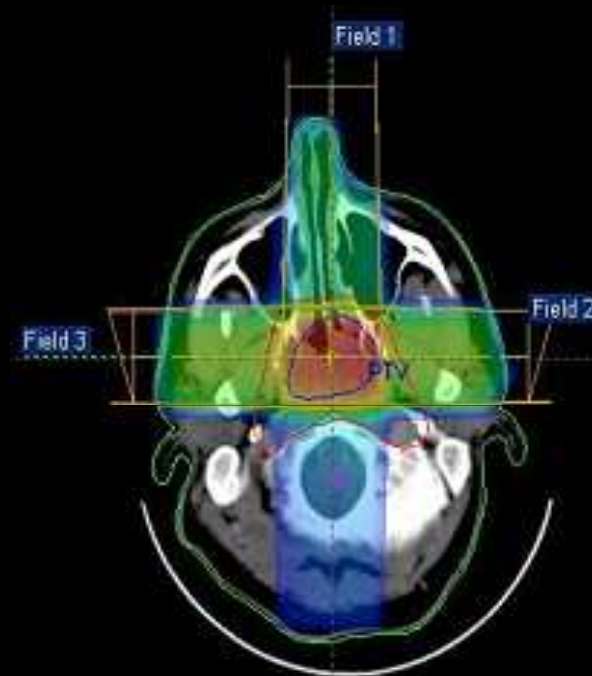
Zunino , Rosato, Lucino, Venencia
Int J Rad Oncol Biol Phys 44: 53-59, 1999



PET/CT in Therapy Planning



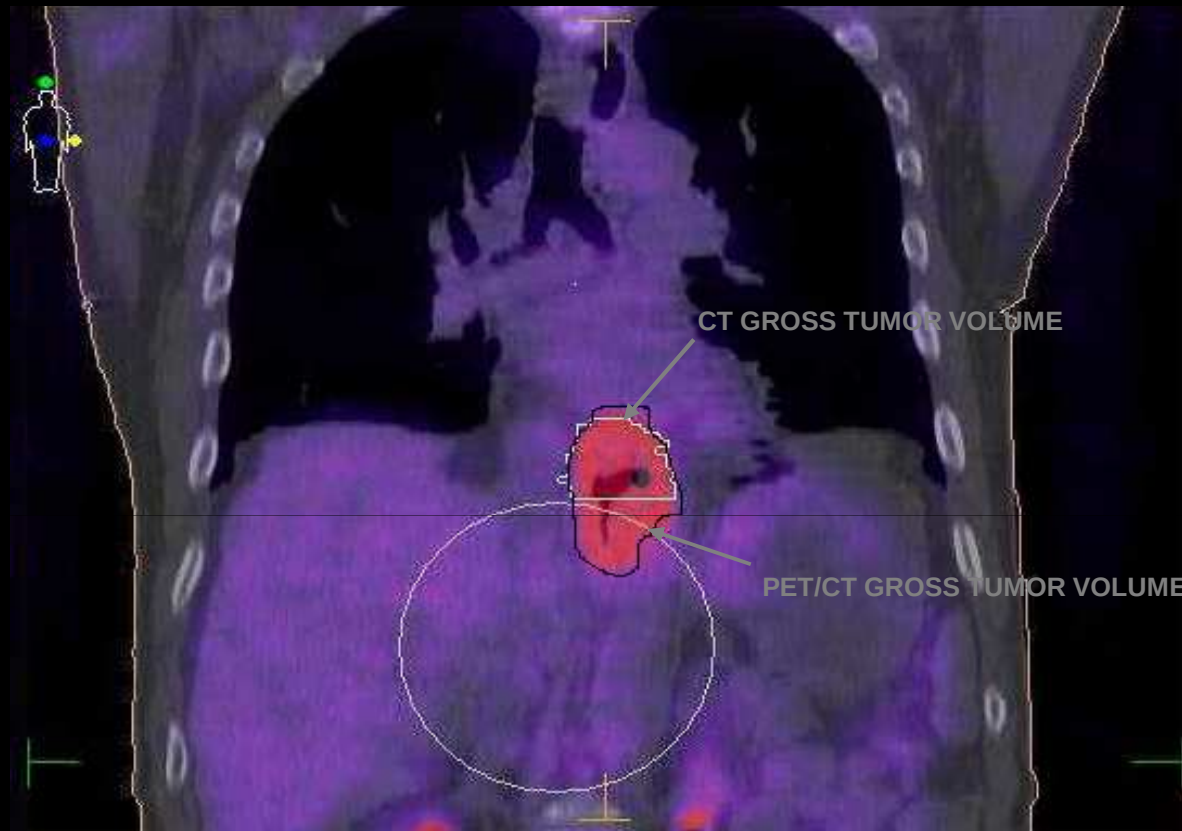
CT-based therapy plan



PET/CT-based therapy plan

significant reduction in plan tumor volume (PTV)

Atención: Hospital Sirio Libanes



Esophageal cancer

60 year-old male diagnosed with esophageal cancer of the distal esophagus.

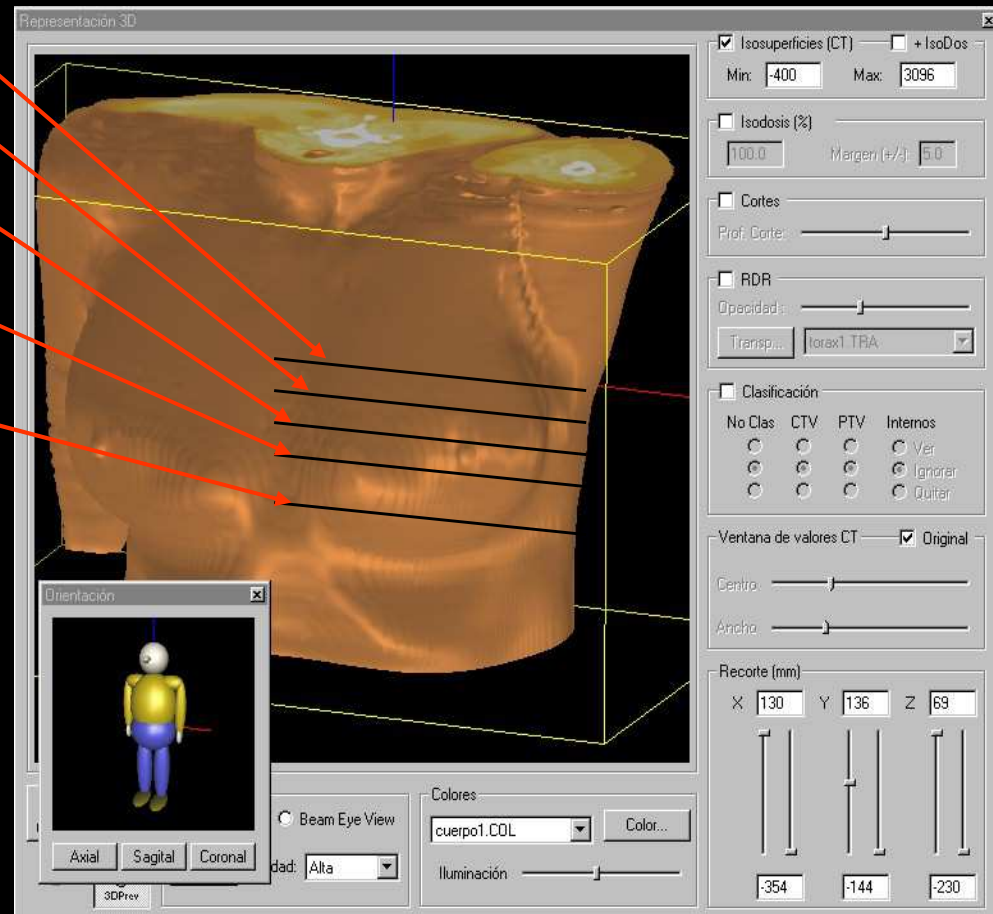
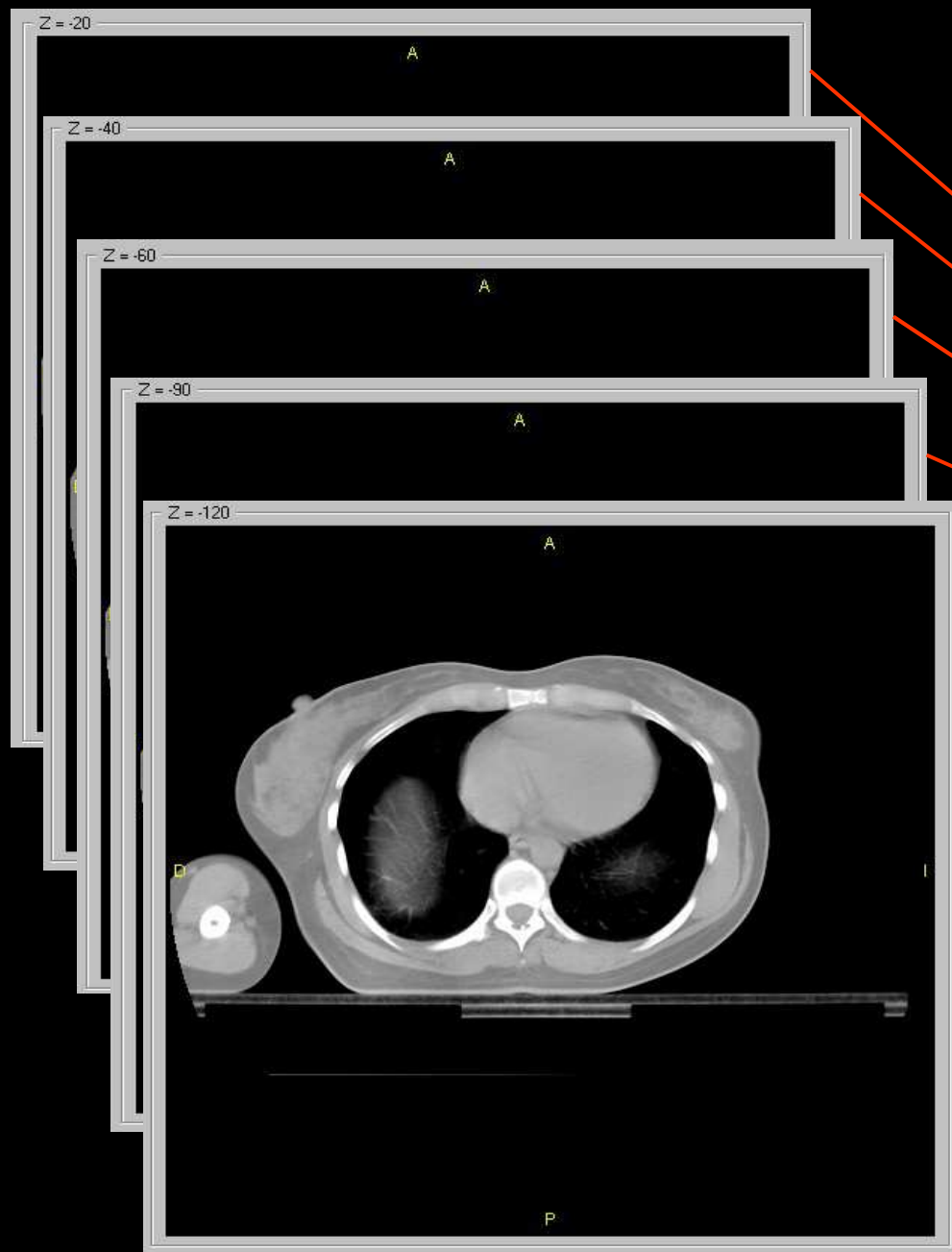
Atención: Hospital Sirio Libanes

Courtesy: St. Johns Mercy, David C. Pratt Cancer Center of Excellence

Simulación virtual y planificación 3D

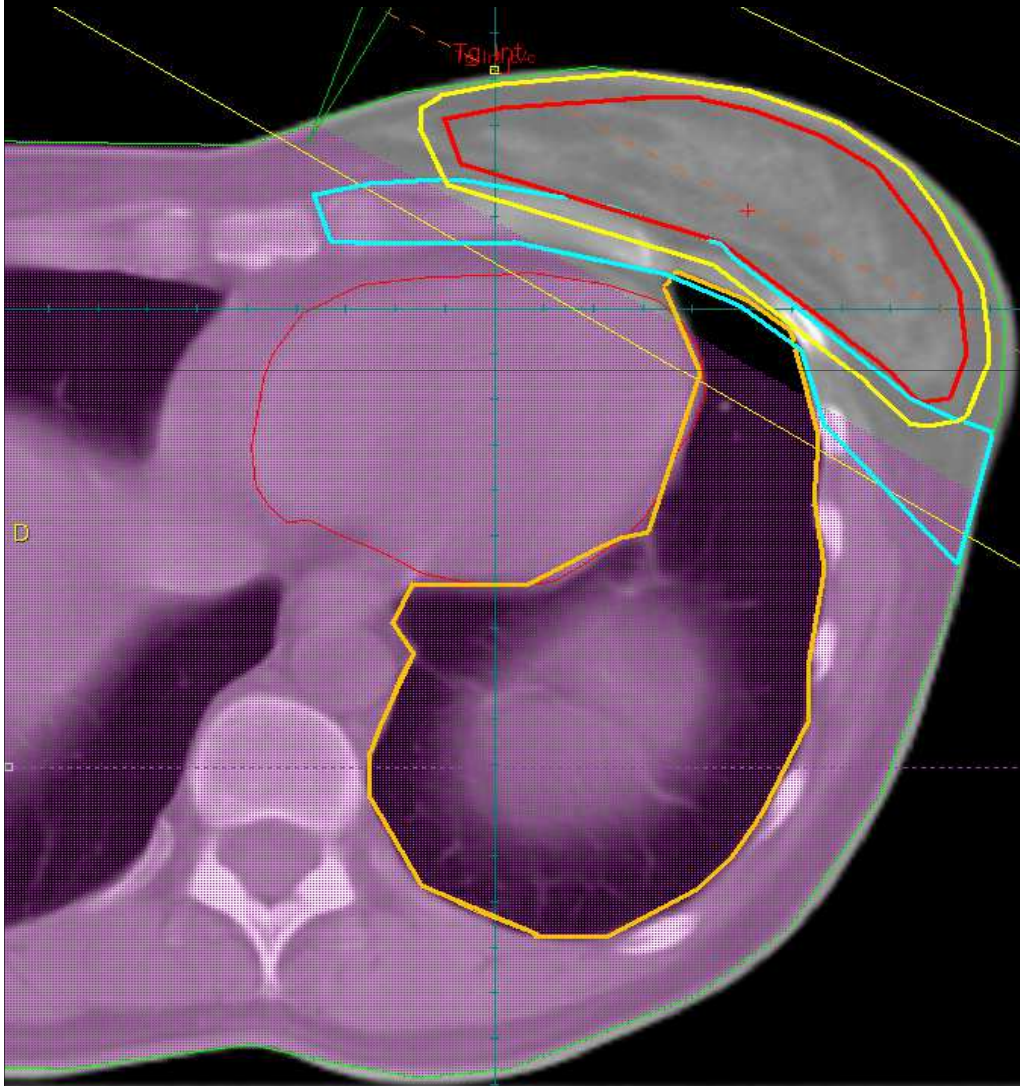
Simulación Virtual

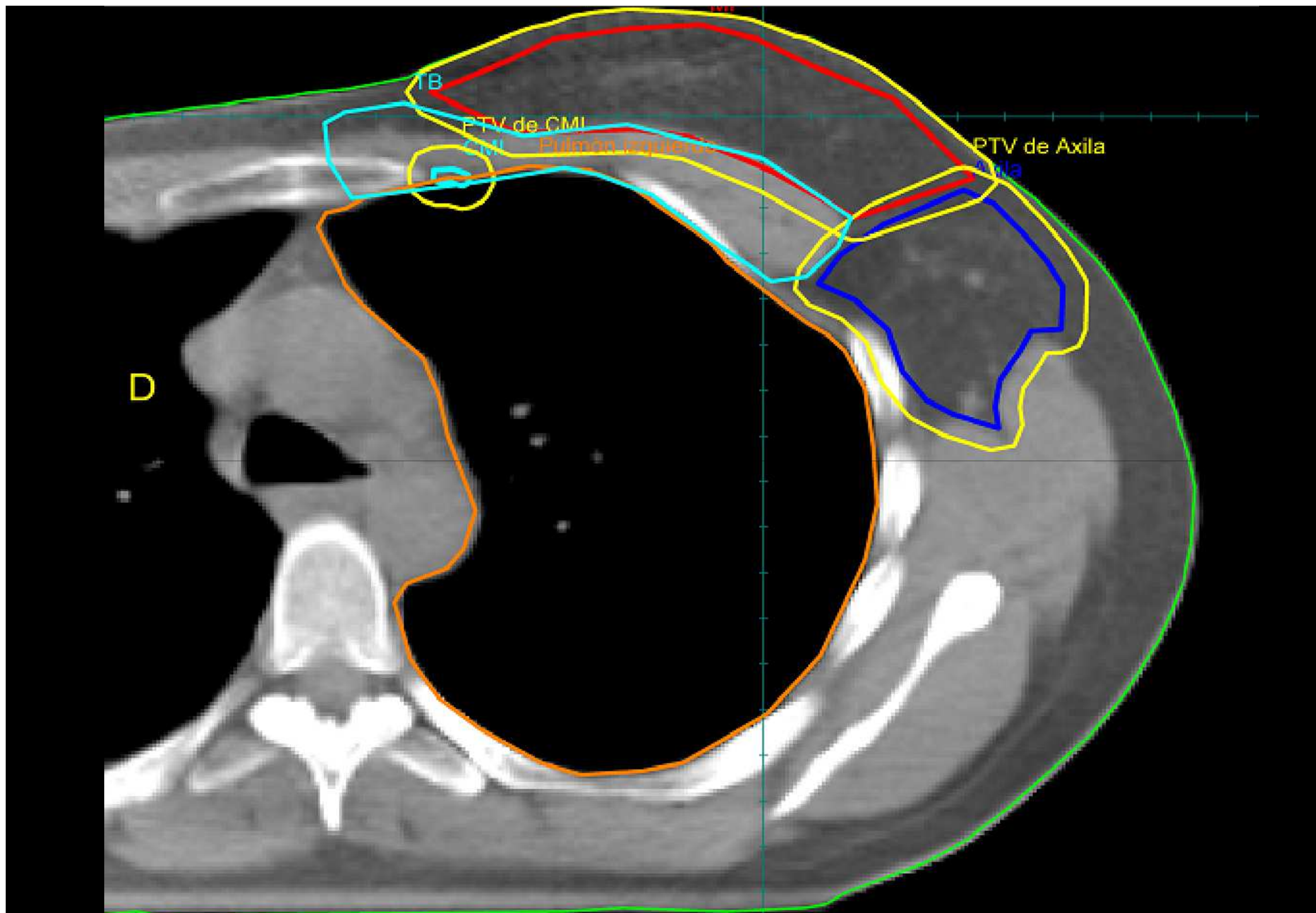




**Corazón cerca de la pared con
y sin conformador**

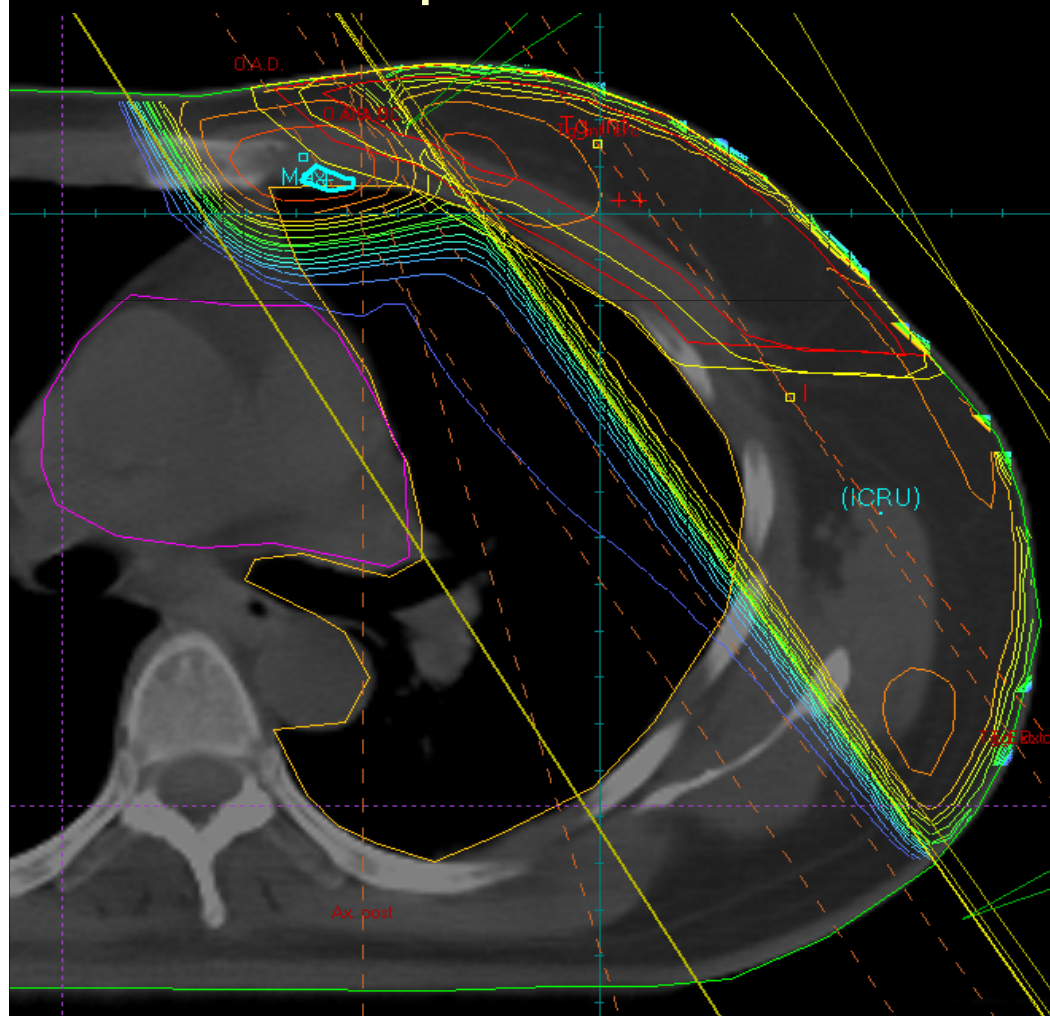
¿por qué 3D?



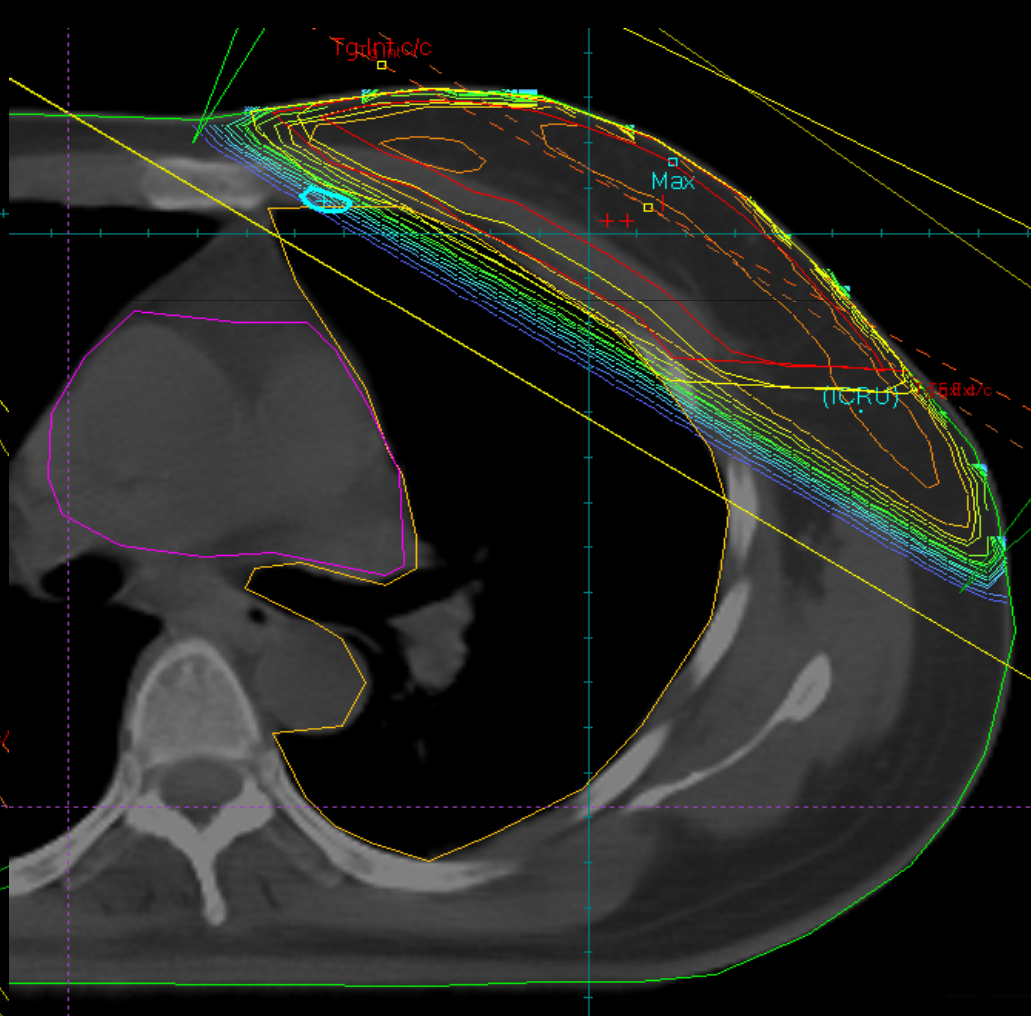


Cadena mamaria interna 3DCRT

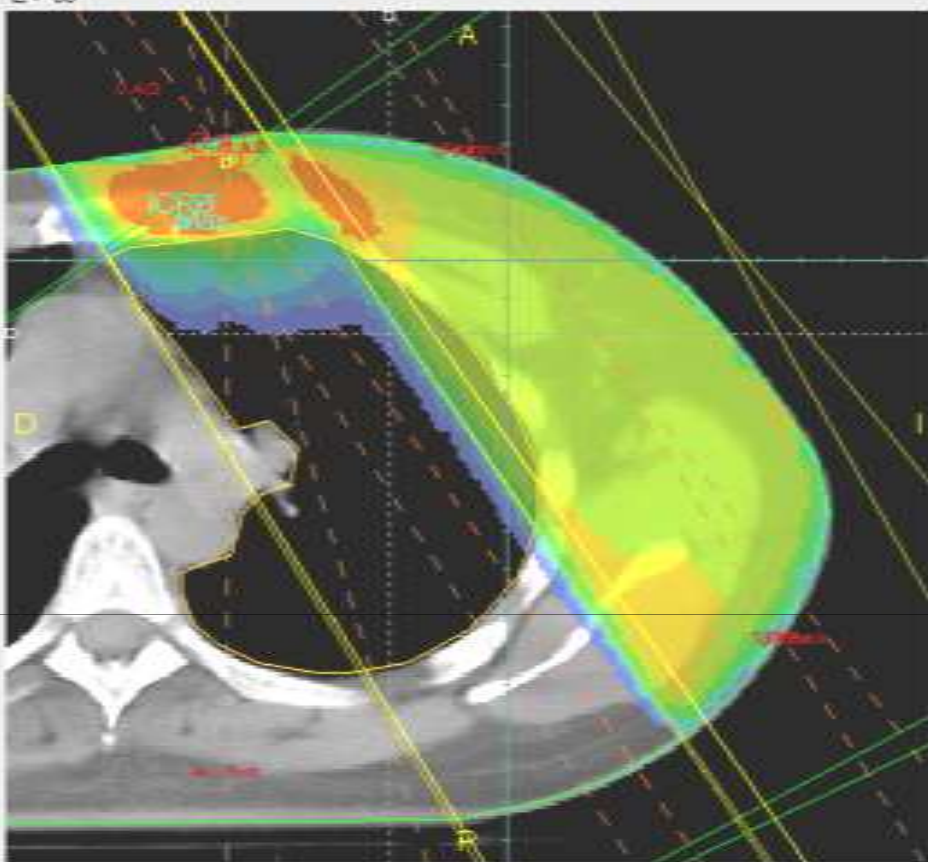
3er. campo



incluida en tangenciales



Z = -30

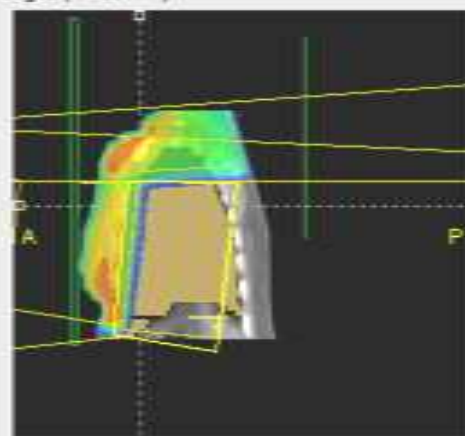


Coordenadas (mm)

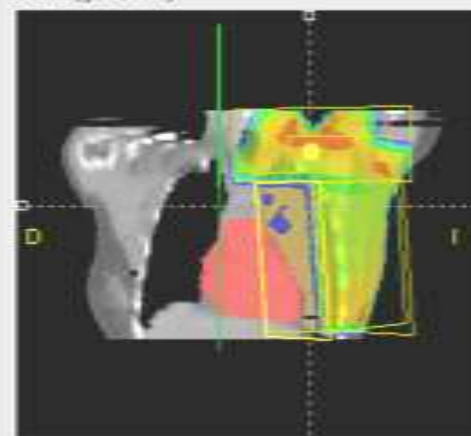
y=282, z=248

220

Sagital (x=-28 mm)



Coronal (y=19 mm)



Coordenadas (mm)

	X	Y	Z	Prof.
Isoc.	67	25	0	0
Entrada	67	25	0	
DPS:	1000	DRL:	1000	DFD:
			454	Isocéntrico

Haz:

- Mama izquierda
- Tg Int. c/c
- Tg Int.
- Tg Ext. c/c
- Tg Ext.
- Ganglios IM (laterales)
- 0.A.D
- Ganglios IM e
- 0.A.D

Haces



Grupos



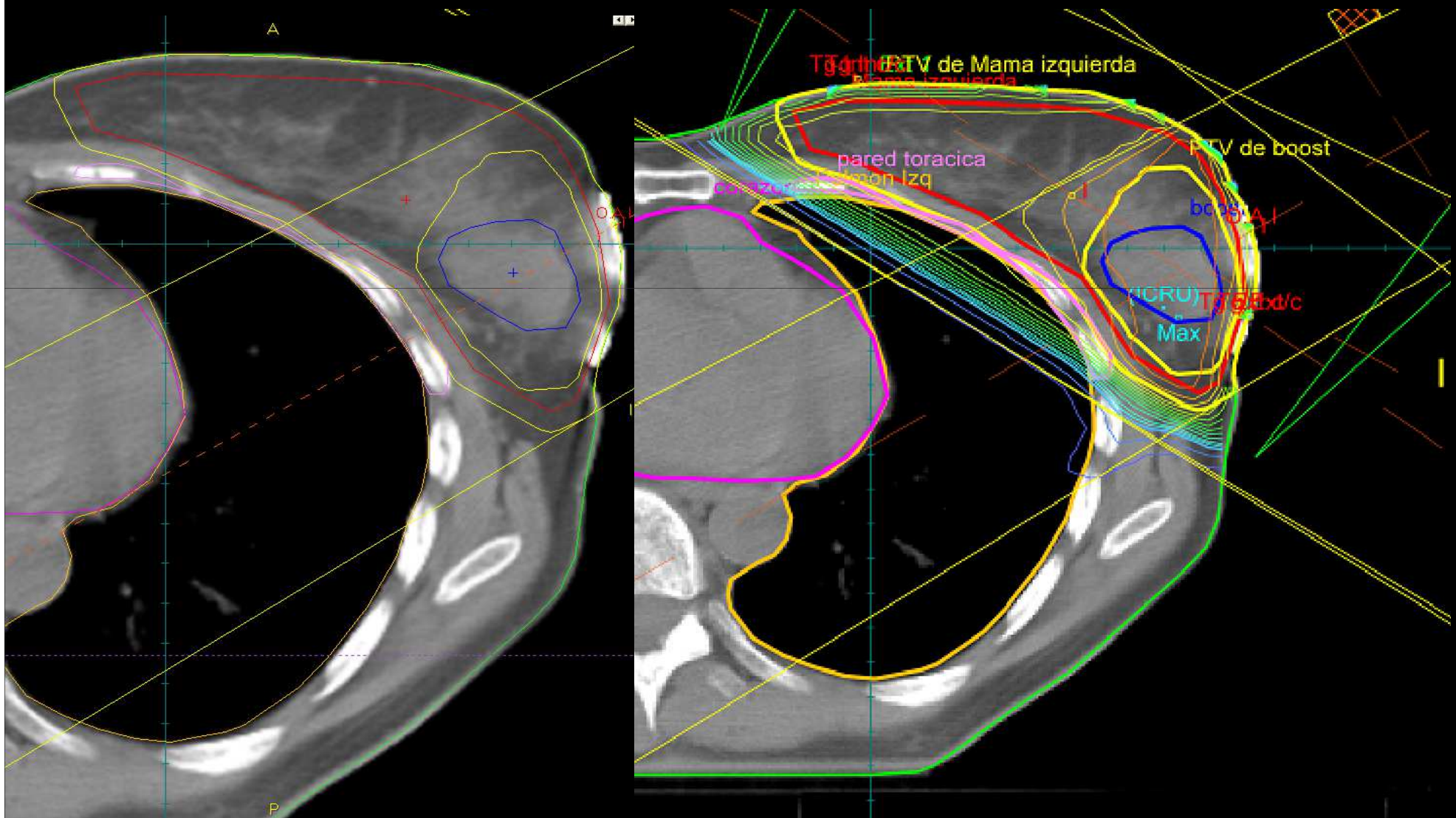
Unidad

SL-15 EMV/MAR

Energía: 6.00 MV



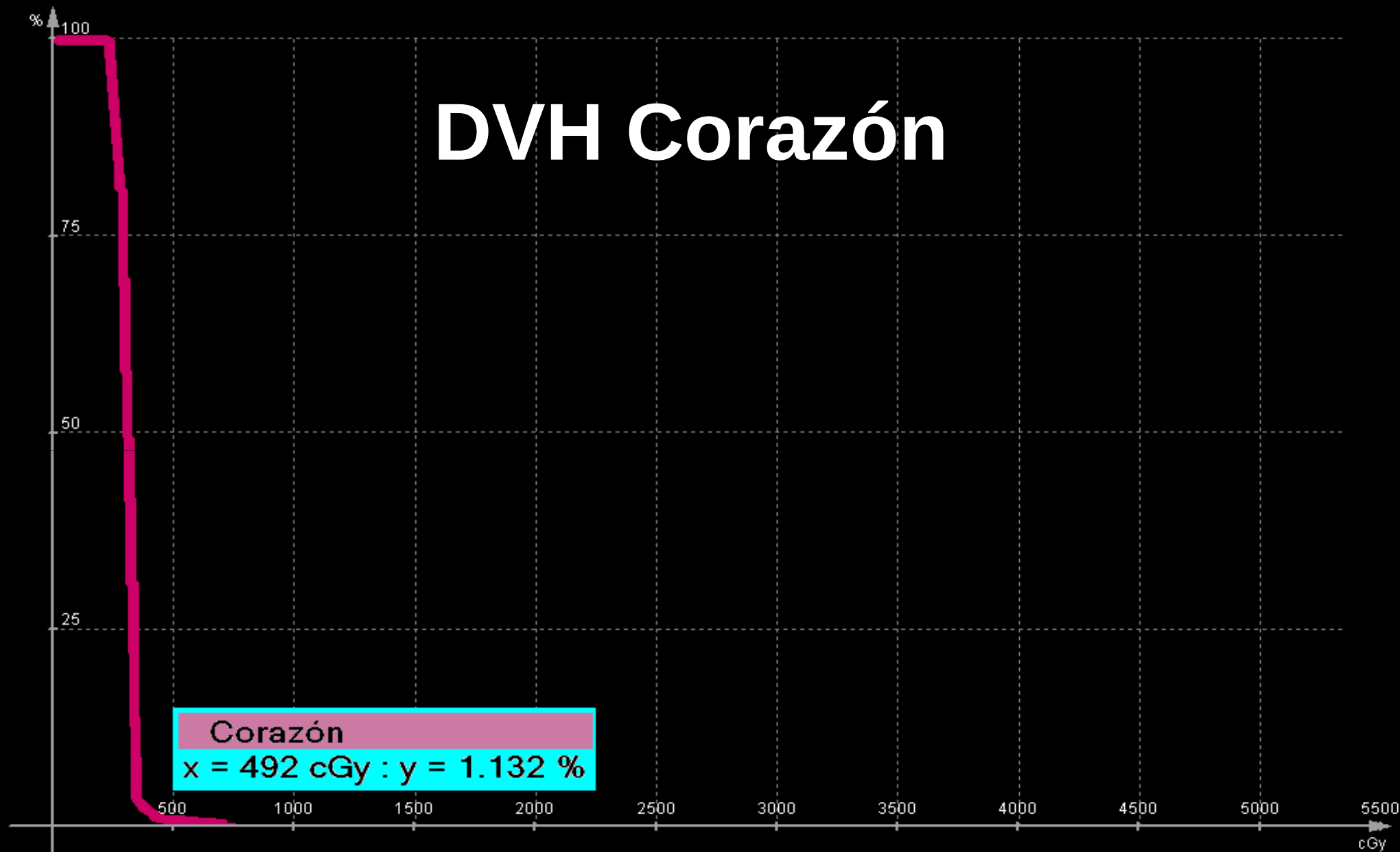
Concepto de “volumen” de Boost - Electrones



CMI



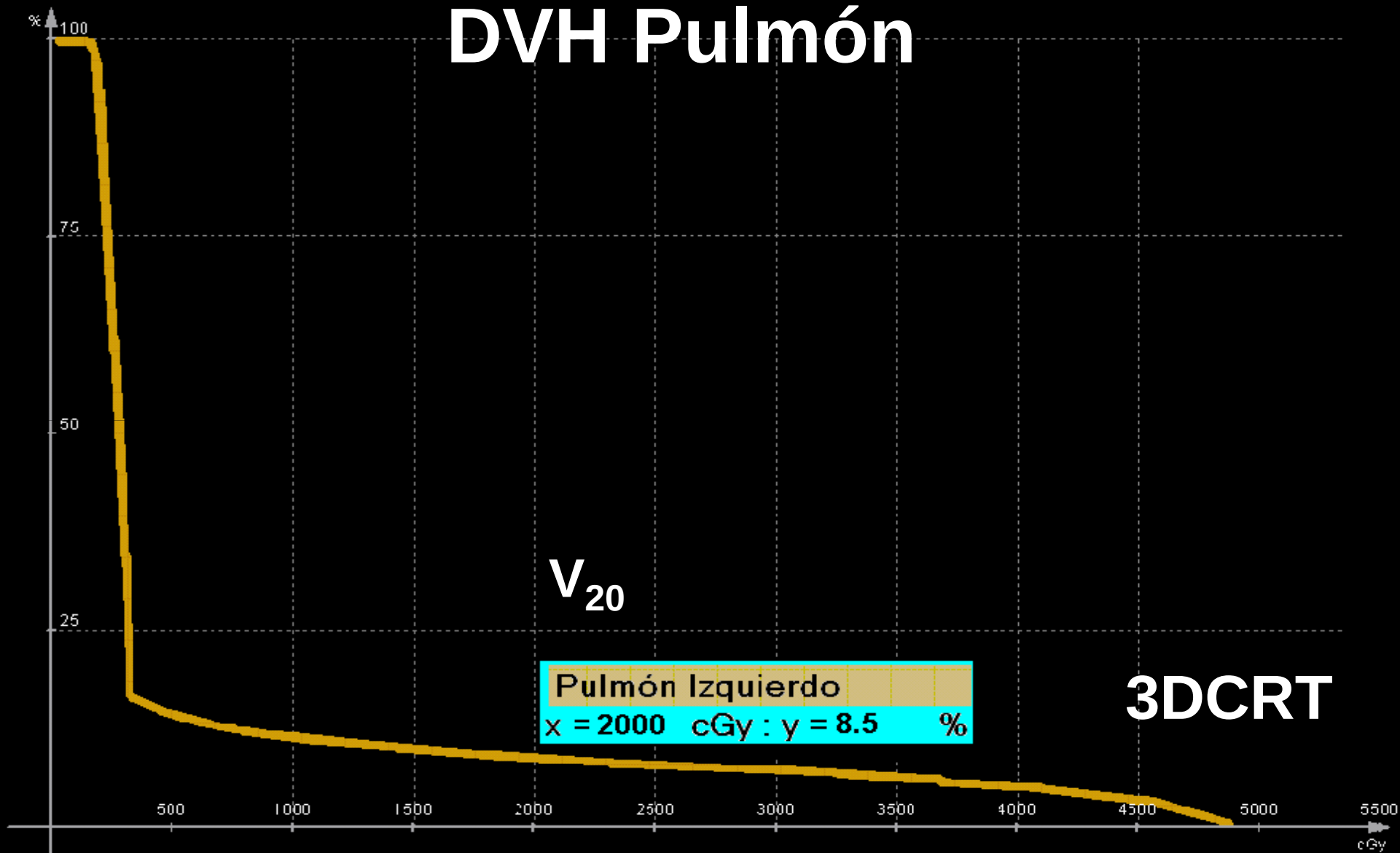
DVH Corazón



Corazón
x = 492 cGy : y = 1.132 %

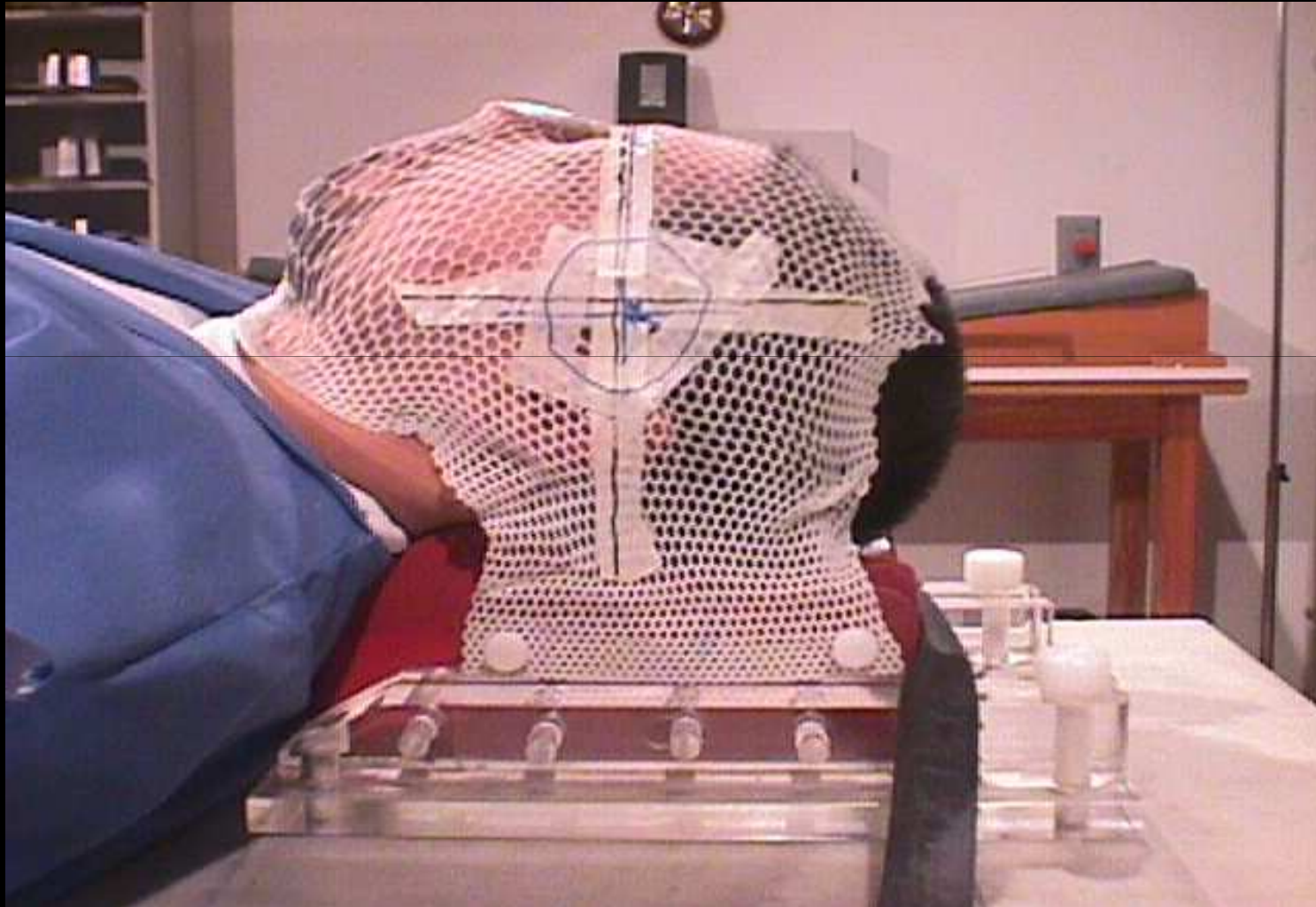


DVH Pulmón



Accesorios para Inmovilización

Inmovilización lámina termoplástica



Bolsas de vacío



Posicionamiento e Inmovilización Próstata



Inmovilización Mama



Beneficio supera riesgo

**TABLE 3. ESTIMATED DISEASE-FREE SURVIVAL
AND OVERALL SURVIVAL.***

VARIABLE	10-YR ACTUARIAL DISEASE-FREE SURVIVAL		10-YR ACTUARIAL OVERALL SURVIVAL	
	RADIOTHERAPY + CMF	CMF ALONE	RADIOTHERAPY + CMF	CMF ALONE
	percent			
All patients	48	34	54	45
Age (yr)				
<40	44	26	55	38
40-49	54	36	59	48
50-59	40	34	45	45
Tumor size (mm)				
<21	57	45	67	58
21-50	43	28	47	38
>50	37	22	40	33
No. of nodes removed				
0-3	42	38	58	48
4-9	50	32	55	45
>9	46	34	49	45
No. of positive nodes				
None	74	62	82	70
1-3	54	39	62	54
>3	27	14	32	20
Frequency of positive nodes (%)				
<34	65	49	70	63
34-67	44	31	51	46
>67	27	15	37	20
Histopathological classifica- tion of tumor†				
Ductal	48	32	54	43
Lobular	36	41	45	53
Medullary	65	54	66	65
Grade of anaplasia (ductal carcinoma only)				
Grade I	63	47	71	62
Grade II	46	29	52	40
Grade III	35	20	39	27

**The New England
Vol. 337, 953, 1997**

TABLE 3. RATES OF SURVIVAL FREE OF SYSTEMIC AND LOCOREGIONAL DISEASE, ACCORDING TO THE NUMBER OF POSITIVE LYMPH NODES.*

DISEASE CATEGORY AND NODAL STATUS	CHEMOTHERAPY	CHEMOTHERAPY AND RADIOTHERAPY	P VALUE	RELATIVE RISK (95% CONFIDENCE INTERVAL)
	percent surviving			
Systemic disease				
1-3 Positive nodes			0.06	0.65 (0.41-1.02)
5 yr	66	79		
10 yr	53	68		
15 yr	49	63		
≥4 Positive nodes			0.05	0.64 (0.41-1.00)
5 yr	39	52		
10 yr	24	44		
15 yr	20	33		
Locoregional disease				
1-3 Positive nodes			1.17	0.55 (0.23-1.30)
5 yr	84	93		
10 yr	84	90		
15 yr	67	90		
≥4 Positive nodes			0.04	0.45 (0.20-0.98)
5 yr	72	82		
10 yr	59	79		

The New England.Vol. 337 pag. 961,1997

2005

Long-term mortality from heart disease and lung cancer after radiotherapy for early breast cancer: prospective cohort study of about 300.000 women in US SEER cancer registries

The Lancet Oncology (6), August 2005

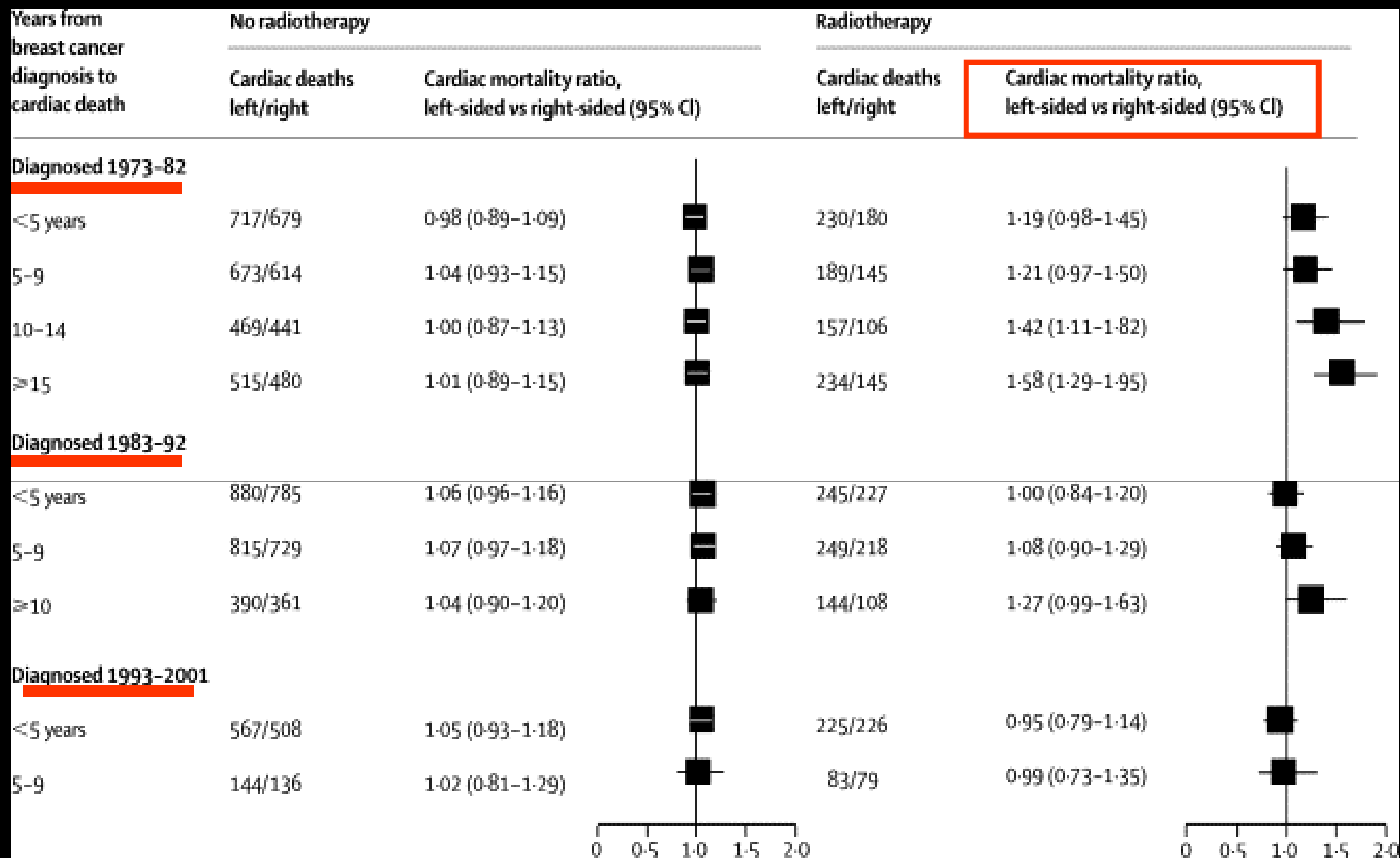


Figure 2 Left-sided versus right-sided breast cancer: subsequent cardiac mortality ratios by radiotherapy status, period of diagnosis, and years from breast cancer diagnosis to cardiac death.

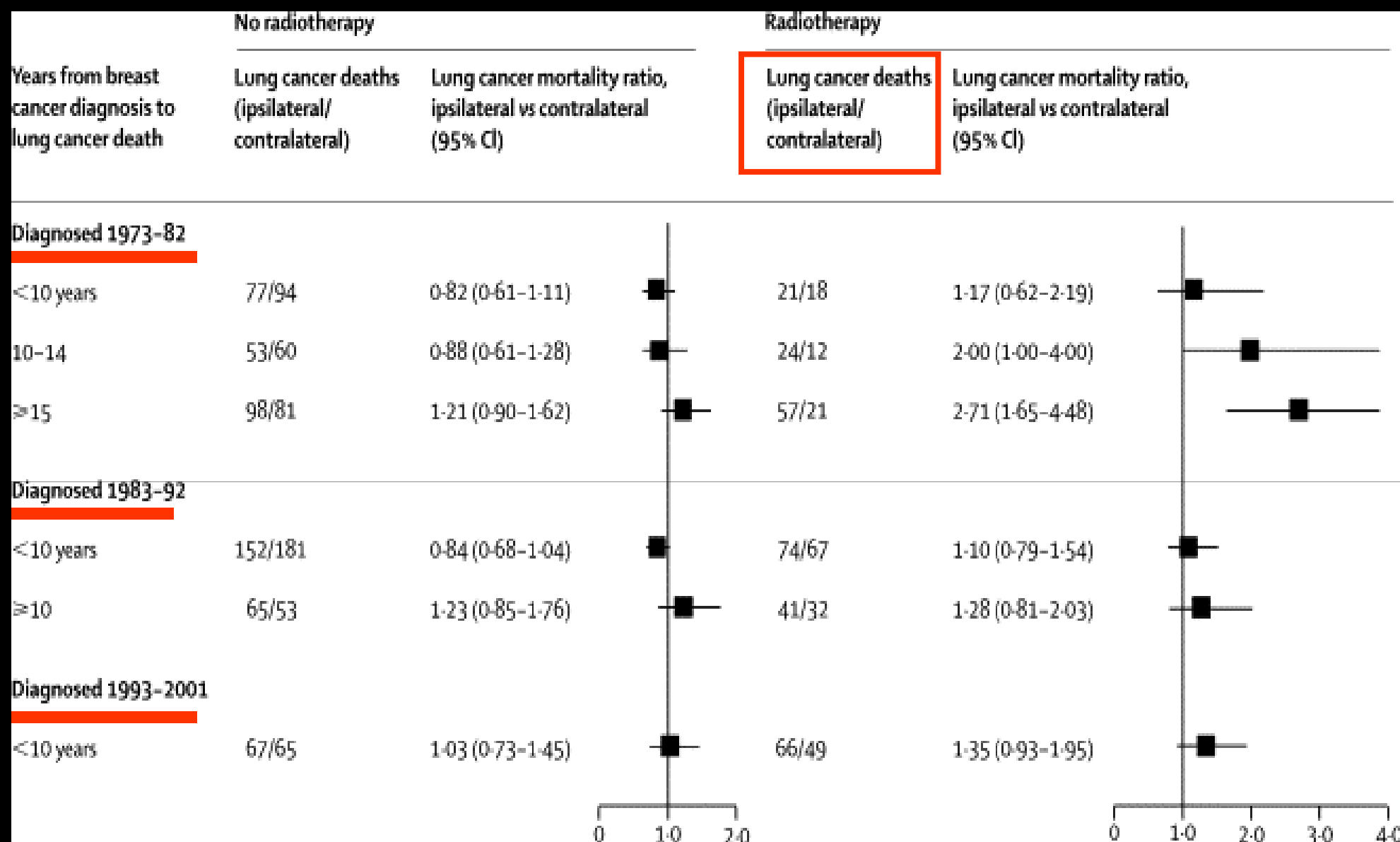


Figure 3 Unilateral breast cancer: subsequent ipsilateral versus contralateral lung cancer mortality ratios by radiotherapy status, period of breast cancer diagnosis, and years from breast cancer diagnosis to lung cancer death.

- **EBCTCG 2005**
- **Ragaz a 20 años**
- **DBCG b&c a 15 años**

Ensayo Randomizado Fase III RTPM / Actualización 2007

DBCG 82 b & c 3.083 pacientes pre y
posmenopáusicas, alto riesgo

1.152 N+ (gang. disecados 8 ó +) a **15 años**

Subgrupo - SV RT 39% / No RT 29% (p = 0.015)

N4+ SL FLR RT 51% / No RT 10% (p < 0.001)

N+ 1-3 SL FLR RT 27% / No RT 4% (p < 0.001)

SV N+ 1-3 RT 57% vs No RT 48% (p = 0.03)

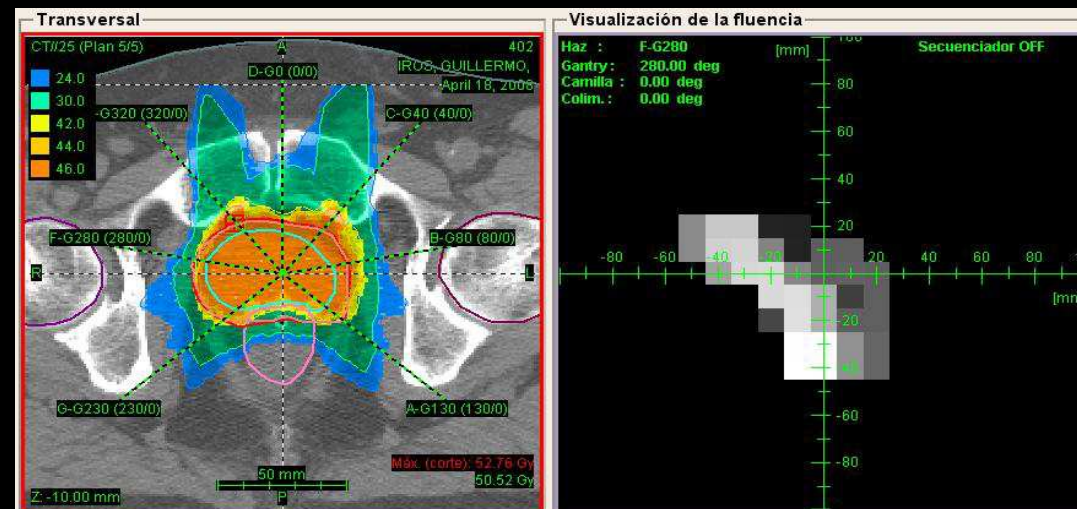
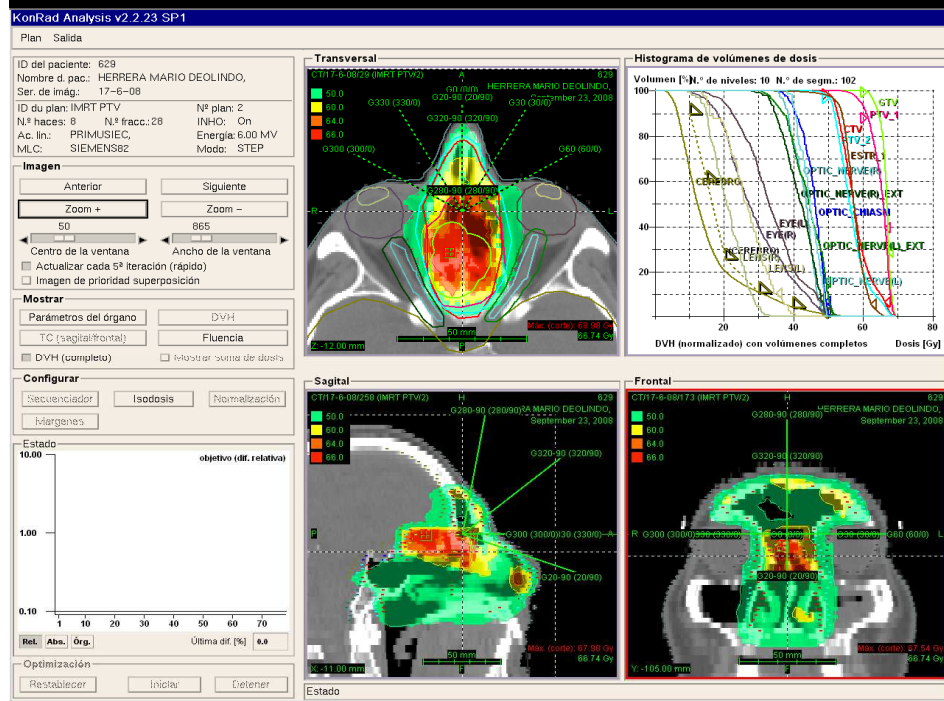
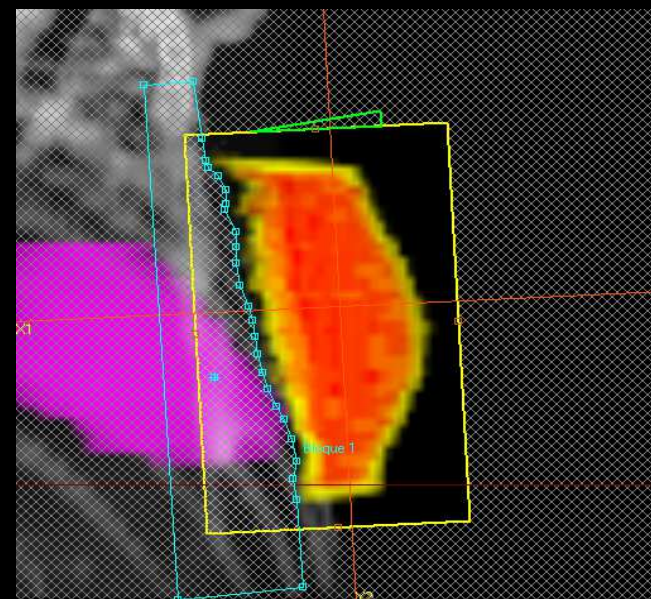
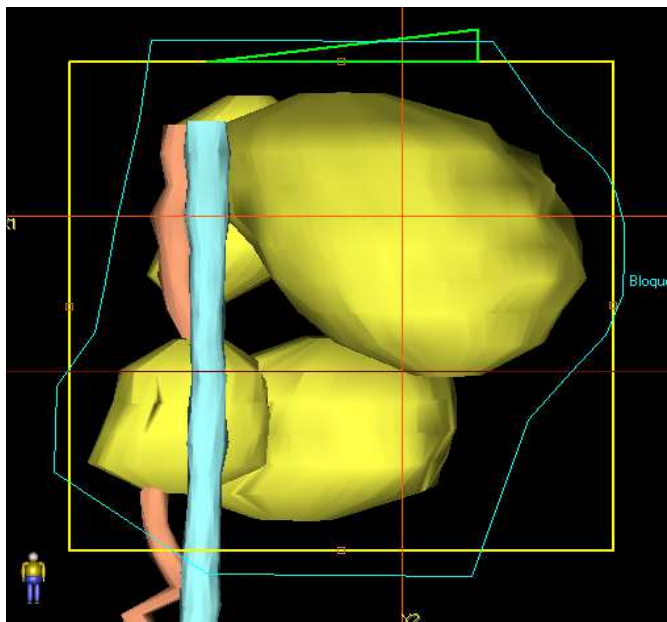
N4+ RT 21% vs No RT 12% (p = 0.03)

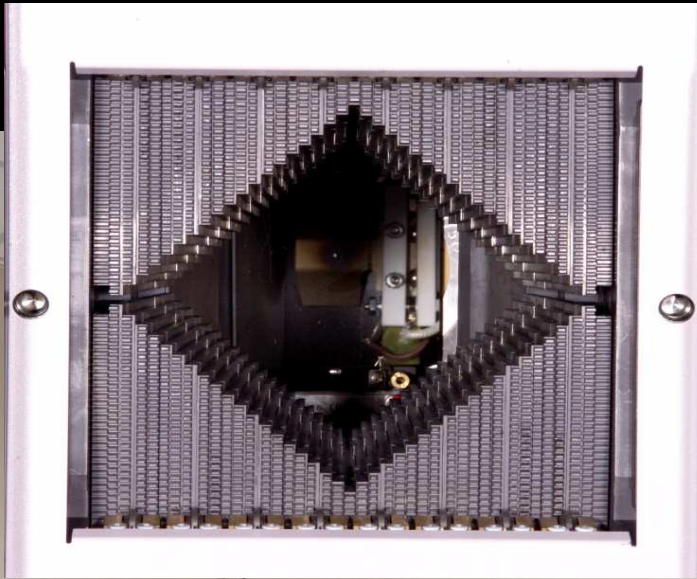
Overgaard. Radiotherapy & Oncology 82 (3): 247,2007

Presente

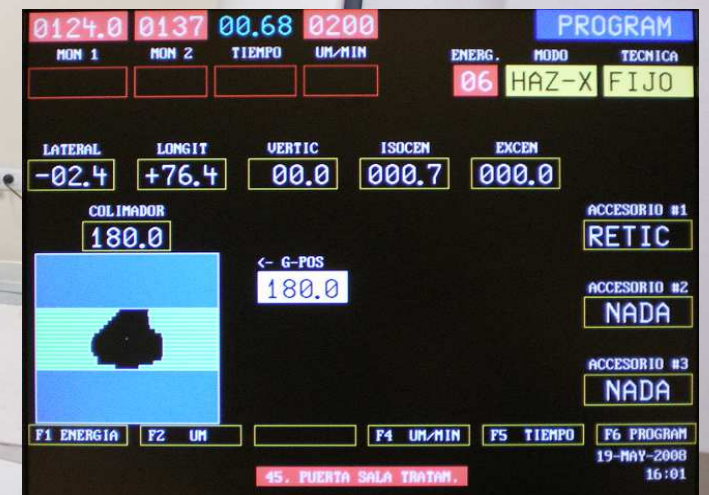
“Lo Bueno”

3DCRT a IMRT





Control digital del
Colimador multiláminas



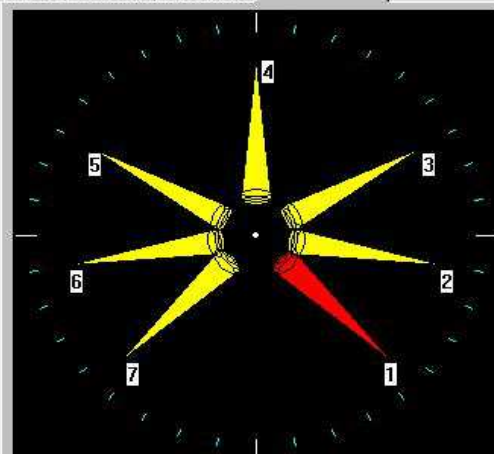
Patient

ID: **N22350**

DOB: **1/5/1944**

Gender: **Varón**

Facts Tx History Prescription Tx Visualization



Group: G135

Gantry(°):	135.0
Coll.(°):	0.0
MV:	6
MU:	60.0
Mode:	XRay
Tech:	Fixed
Segs:	6
MU Del.:	0.0

Patient List Tx Delivery Chart Field Definition Treatment Setup

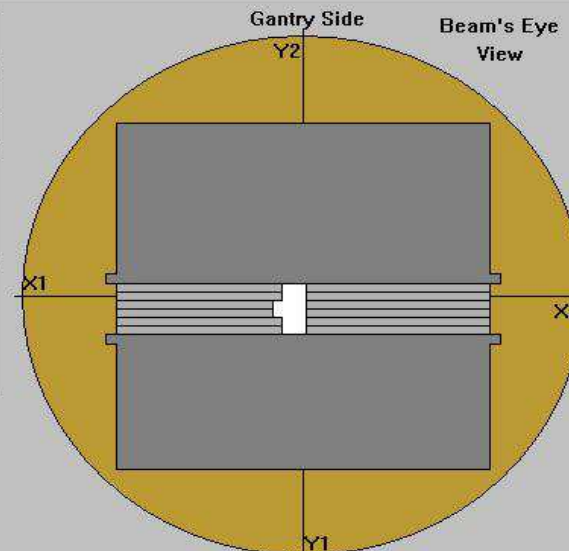
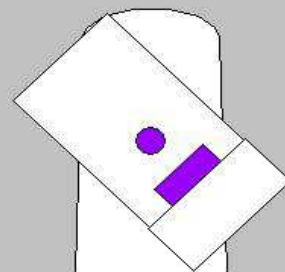
Field ID	Field Name	SSD
G135	G135	83.7

Field Notes

Dosimetry		
Radiation Mode	Energy	MU
X-Ray	6	12.0

Accessories

RETIC



Vertical [cm]

SID [cm]
0.0

Tolerance Table

3-IMRT

Target Machine

PRIMUS IEC

Segment: 1 of 6

For Help, press F1

Sistema de control automático de tratamiento
Lantis, Siemens

Radioterapia guiada por imágenes (IGRT)



Kv cone beam CT

Varian



Elekta

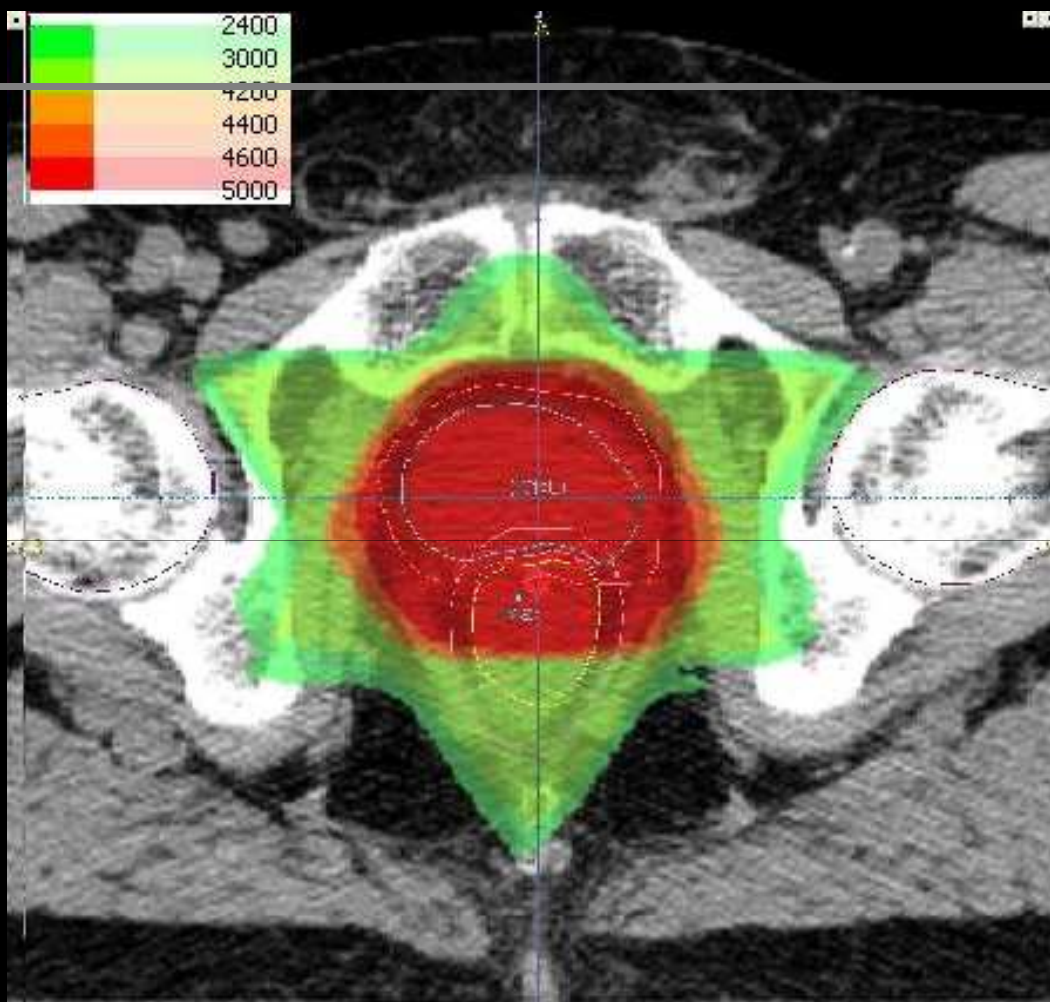
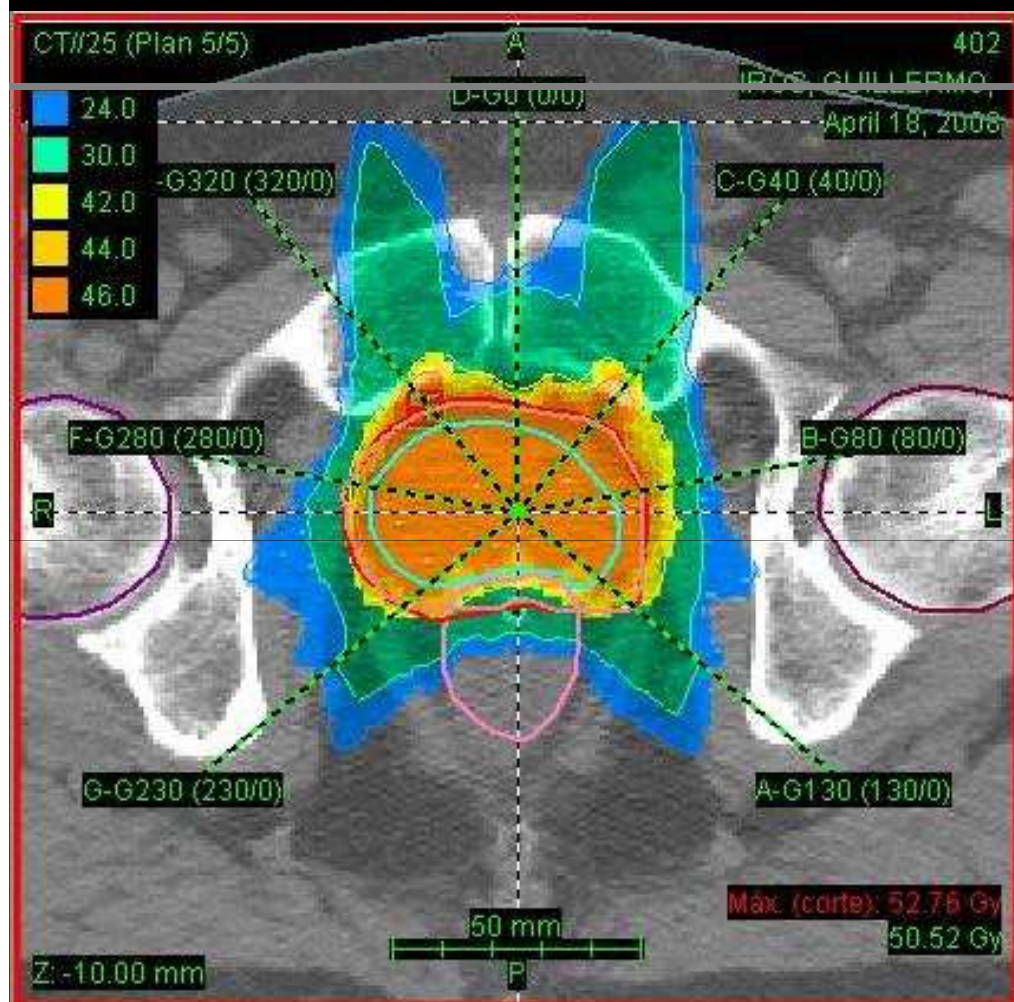


Siemens

MV and kV cone beam CT

Algunos Resultados

Cáncer de próstata IMRT vs 3DCRT



Recto irradiado > 45 Gy reducido de 50% (3DCRT) a 6% IMRT

Vejiga irradiada de 52% a 7%

Int. J. Radiat. Oncol. Biol. Phys 74, 2009. Meta-análisis

ASTRO Online CME

CLINICAL INVESTIGATION

Prostate

HIGHER-THAN-CONVENTIONAL RADIATION DOSES IN LOCALIZED PROSTATE CANCER TREATMENT: A META-ANALYSIS OF RANDOMIZED, CONTROLLED TRIALS

GUSTAVO ARRUDA VIANI, M.D., EDUARDO JOSE STEFANO, M.D., AND SERGIO LUIS AFONSO, M.D.

Department of Radiation Oncology, Marilia School of Medicine, São Paulo, Brazil

Purpose: To determine in a meta-analysis whether the outcomes in men with localized prostate cancer treated with high-dose radiotherapy (HDRT) are better than those in men treated with conventional-dose radiotherapy (CDRT), by quantifying the effect of the total dose of radiotherapy on biochemical control (BC).

Methods and Materials: The MEDLINE, EMBASE, CANCERLIT, and Cochrane Library databases, as well as the proceedings of annual meetings, were systematically searched to identify randomized, controlled studies comparing HDRT with CDRT for localized prostate cancer. To evaluate the dose–response relationship, we conducted a meta-regression analysis of BC ratios by means of weighted linear regression.

Results: Seven RCTs with a total patient population of 2812 were identified that met the study criteria. Pooled results from these RCTs showed a significant reduction in the incidence of biochemical failure in those patients with prostate cancer treated with HDRT ($p < 0.0001$). However, there was no difference in the mortality rate ($p = 0.38$) and specific prostate cancer mortality rates ($p = 0.45$) between the groups receiving HDRT and CDRT. However, there were more cases of late Grade >2 gastrointestinal toxicity after HDRT than after CDRT. In the subgroup analysis, patients classified as being at low ($p = 0.007$), intermediate ($p < 0.0001$), and high risk ($p < 0.0001$) of biochemical failure all showed a benefit from HDRT. The meta-regression analysis also detected a linear correlation between the total dose of radiotherapy and biochemical failure ($BC = -67.3 + [1.8 \times \text{radiotherapy total dose in Gy}]$; $p = 0.04$).

Conclusions: Our meta-analysis showed that HDRT is superior to CDRT in preventing biochemical failure in low-, intermediate-, and high-risk prostate cancer patients, suggesting that this should be offered as a treatment for all patients, regardless of their risk status. © 2009 Elsevier Inc.

Prostate cancer, High-dose radiotherapy, Biochemical control, Mortality, Meta-analysis.

KonRad Analysis v2.2.23 SP1

Plan Salida

ID del paciente: 629
 Nombre d. pac.: HERRERA MARIO DEOLINDO,
 Ser. de imág.: 17-6-08
 ID du plan: IMRT PTV N° plan: 2
 N° haces: 8 N° fracc.: 28 INHO: On
 Ac. lin.: PRIMUSIEC, Energía: 6.00 MV
 MLC: SIEMENS82 Modo: STEP

Imagen

Anterior

Zoom +

50 865

Centro de la ventana Ancho de la ventana

☐ Actualizar cada 5ª iteración (rápido)

☐ Imagen de prioridad superposición

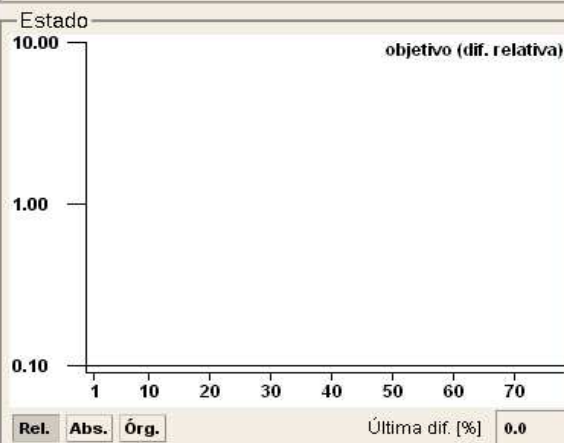
Mostrar

Parámetros del órgano

TC (sagital/frontal)

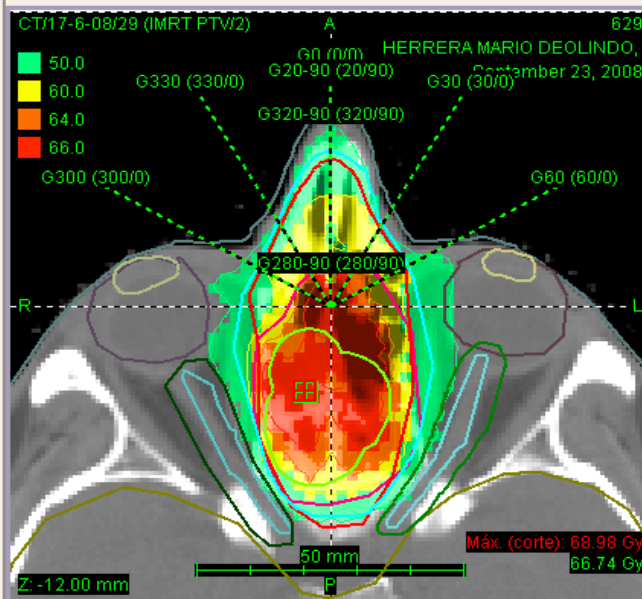
☐ DVH (completo) ☐ Mostrar suma de dosis

Configurar

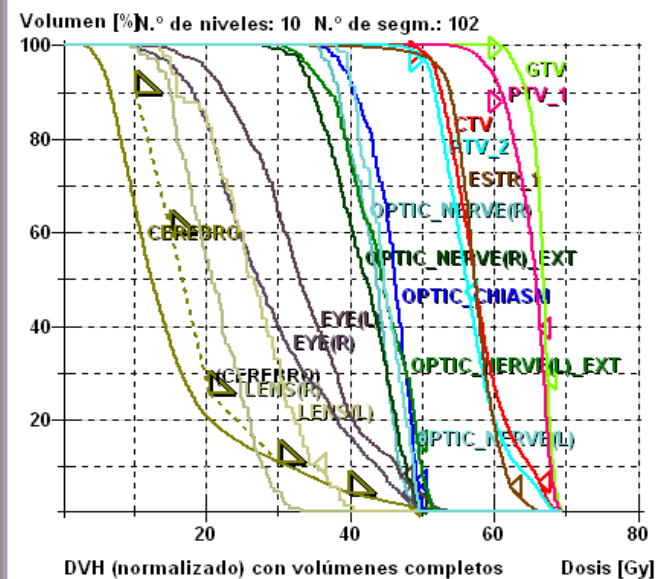


Optimización

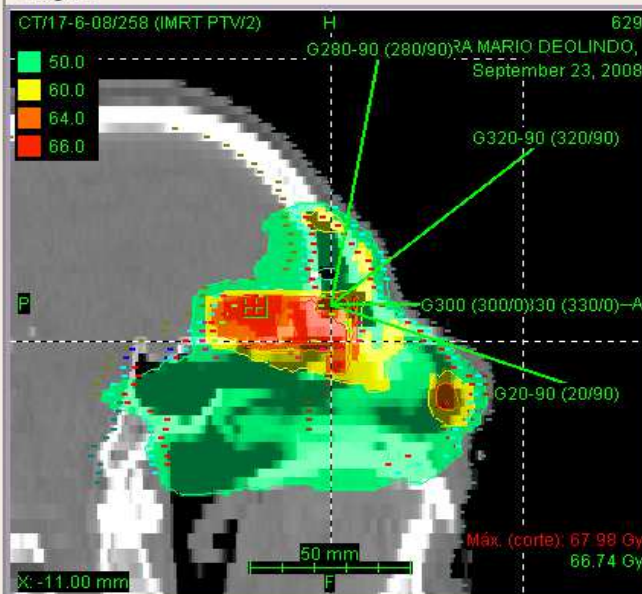
Transversal



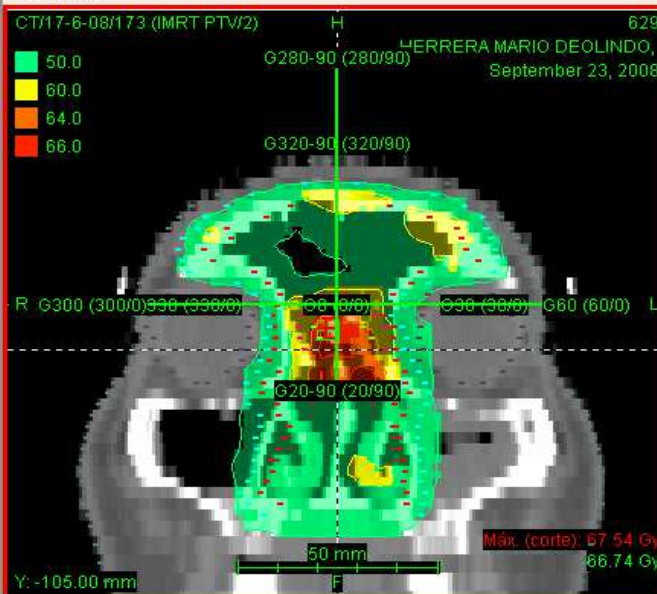
Histograma de volúmenes de dosis



Sagital

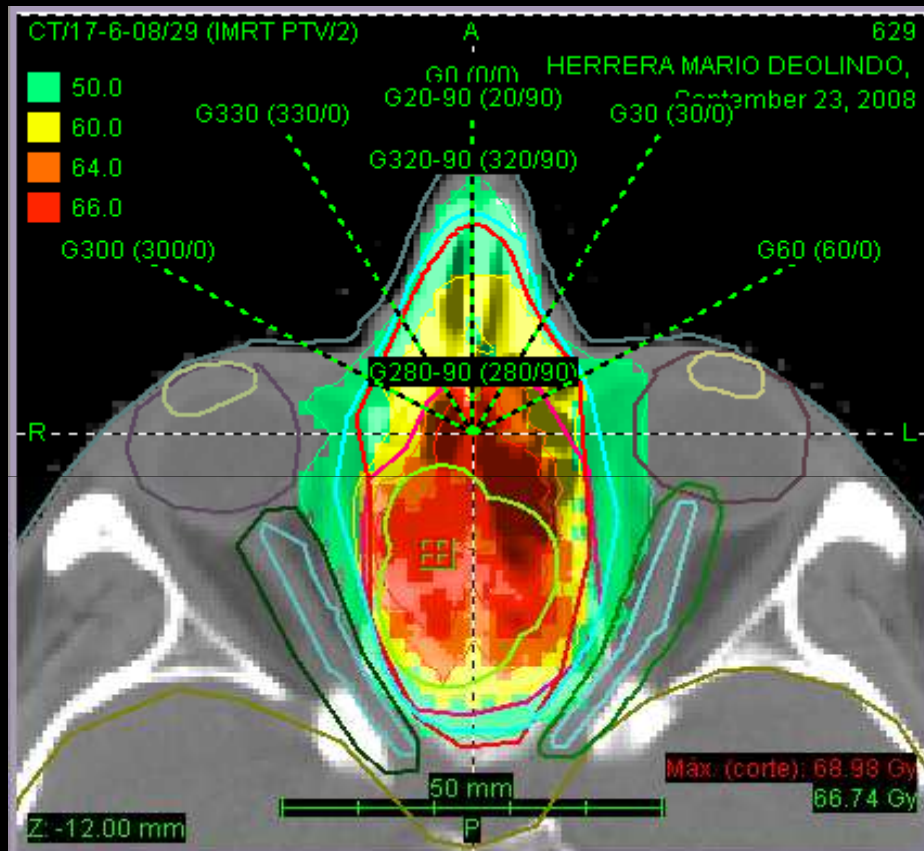


Frontal

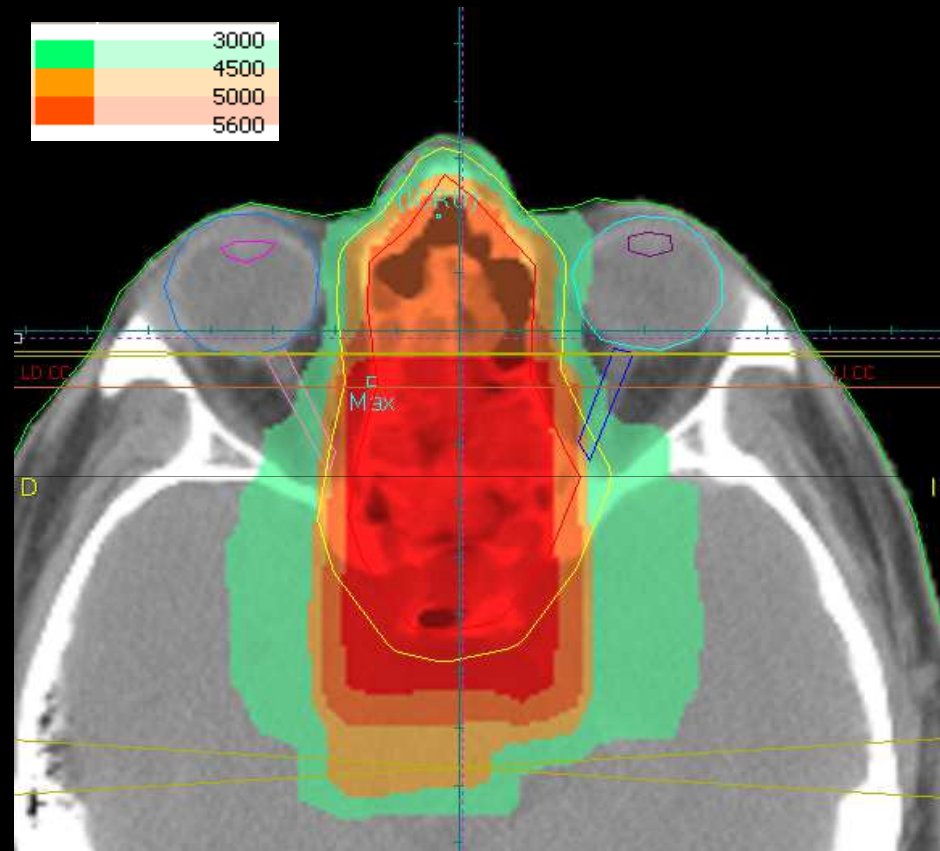


Estado

1 paciente con 2 planes: Senos nasales y paranasales

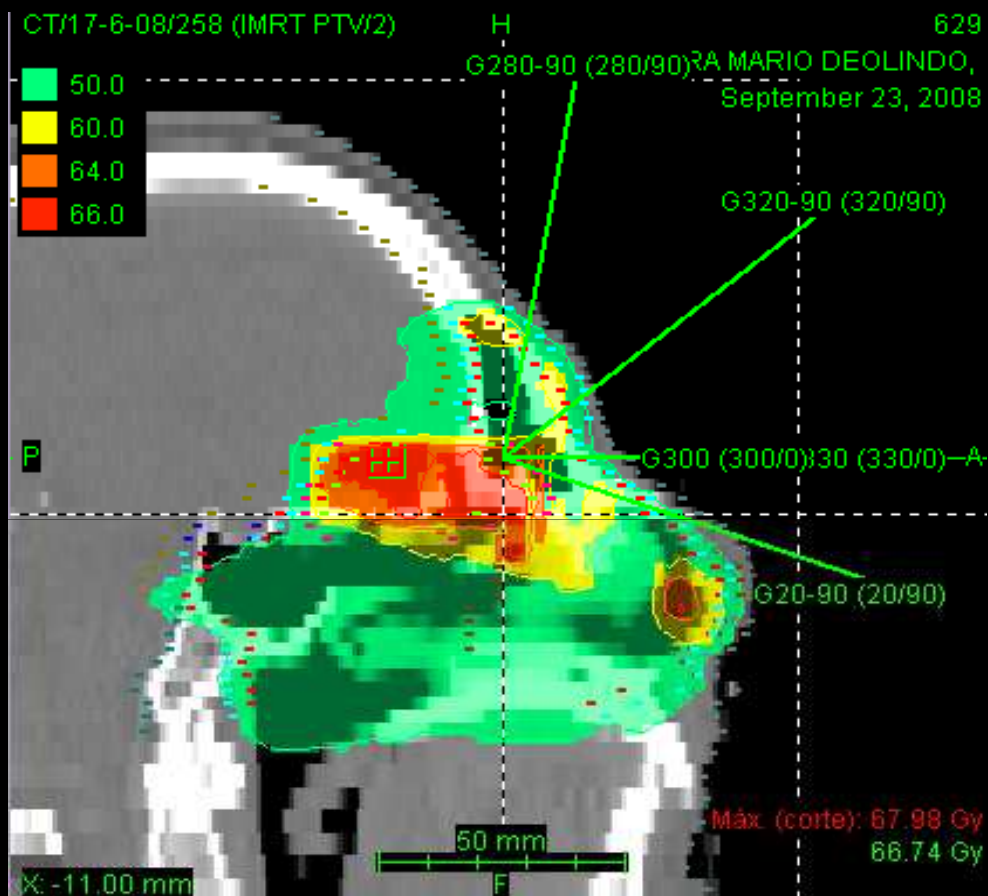


IMRT

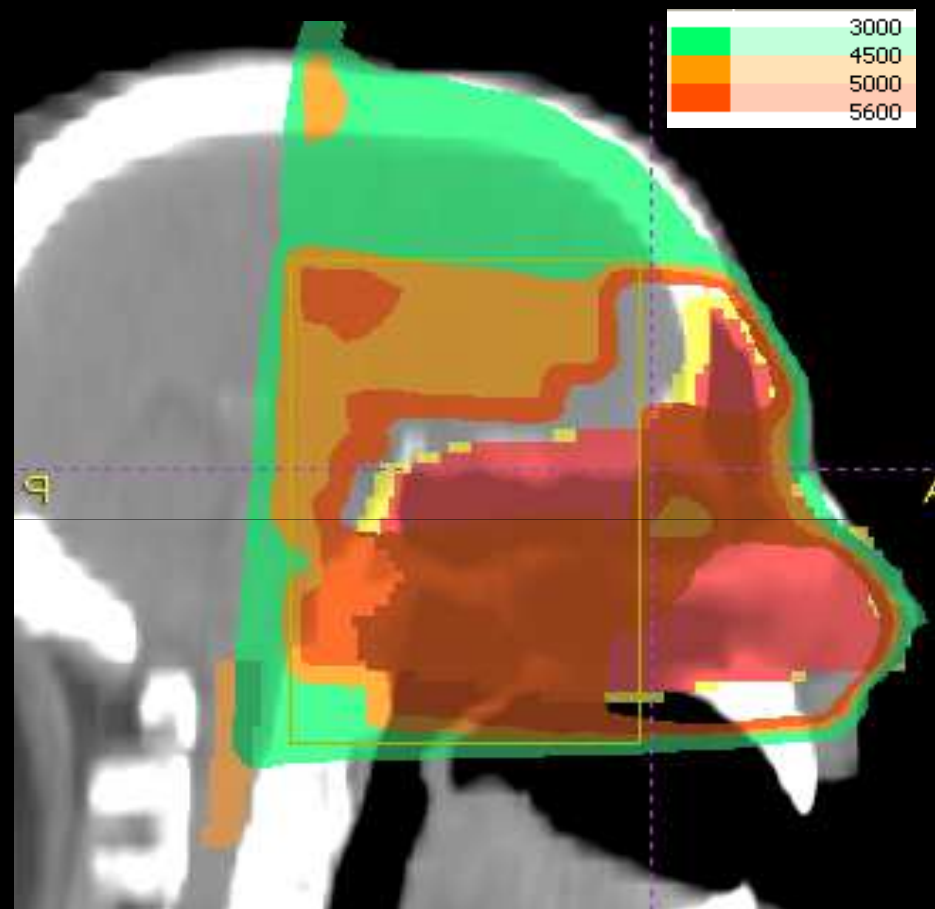


3DCRT

1 paciente con 2 planes: Senos nasales y paranasales

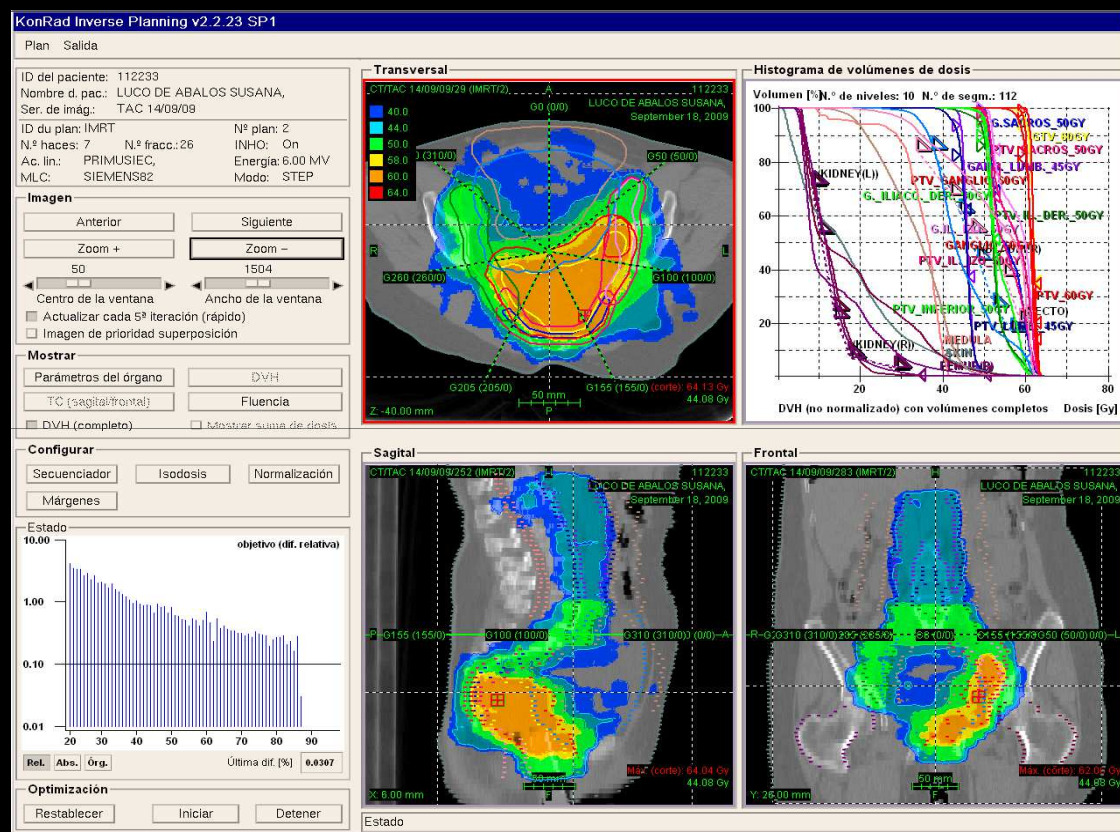


IMRT

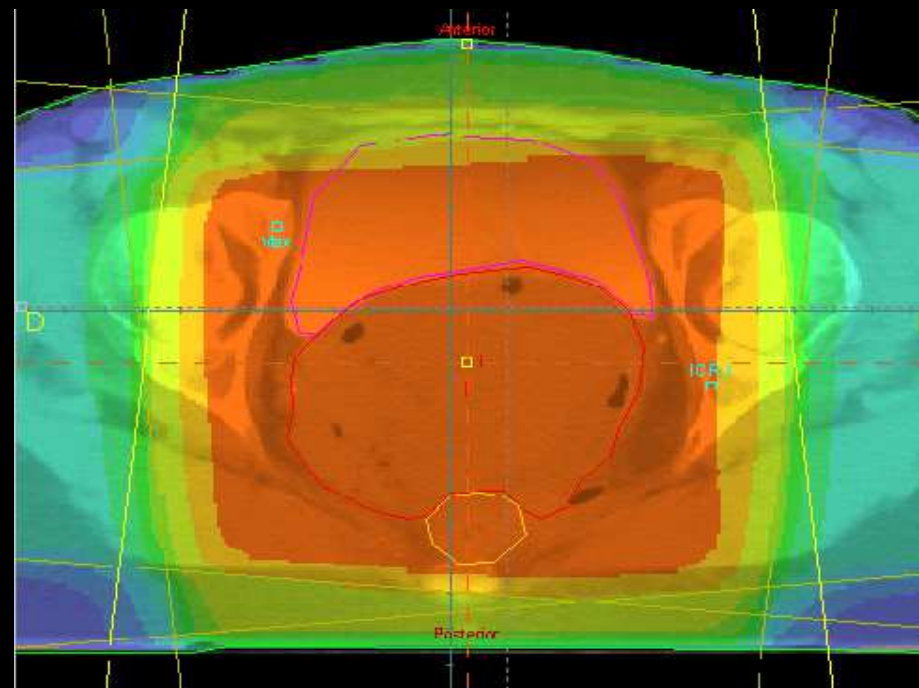


3DCRT

Cuello Uterino



IMRT



3DCRT

Helical Tomotherapy

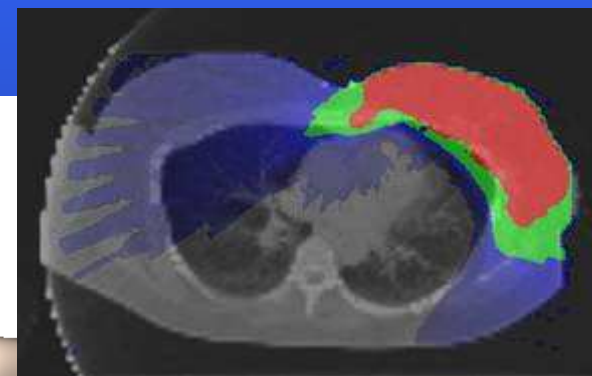
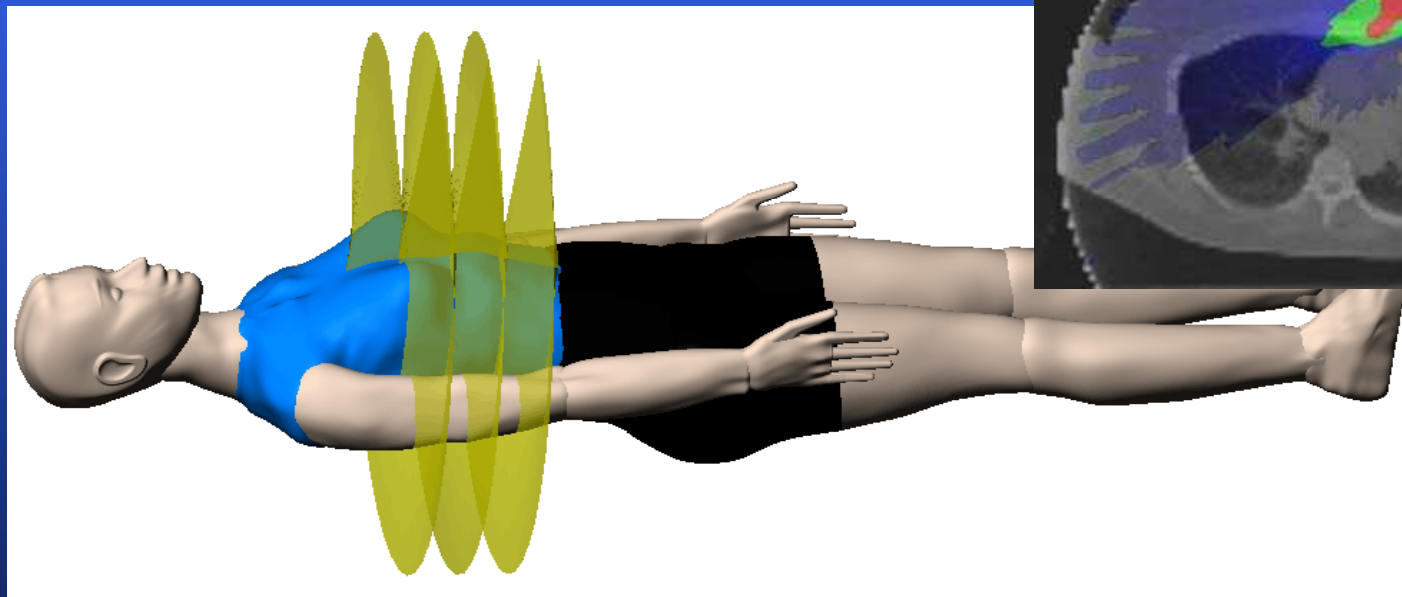


Atención Dr. Carlos Perez

Técnicas para Mama: Helical y Topoterapia

TomoTherapy Hi-ART System

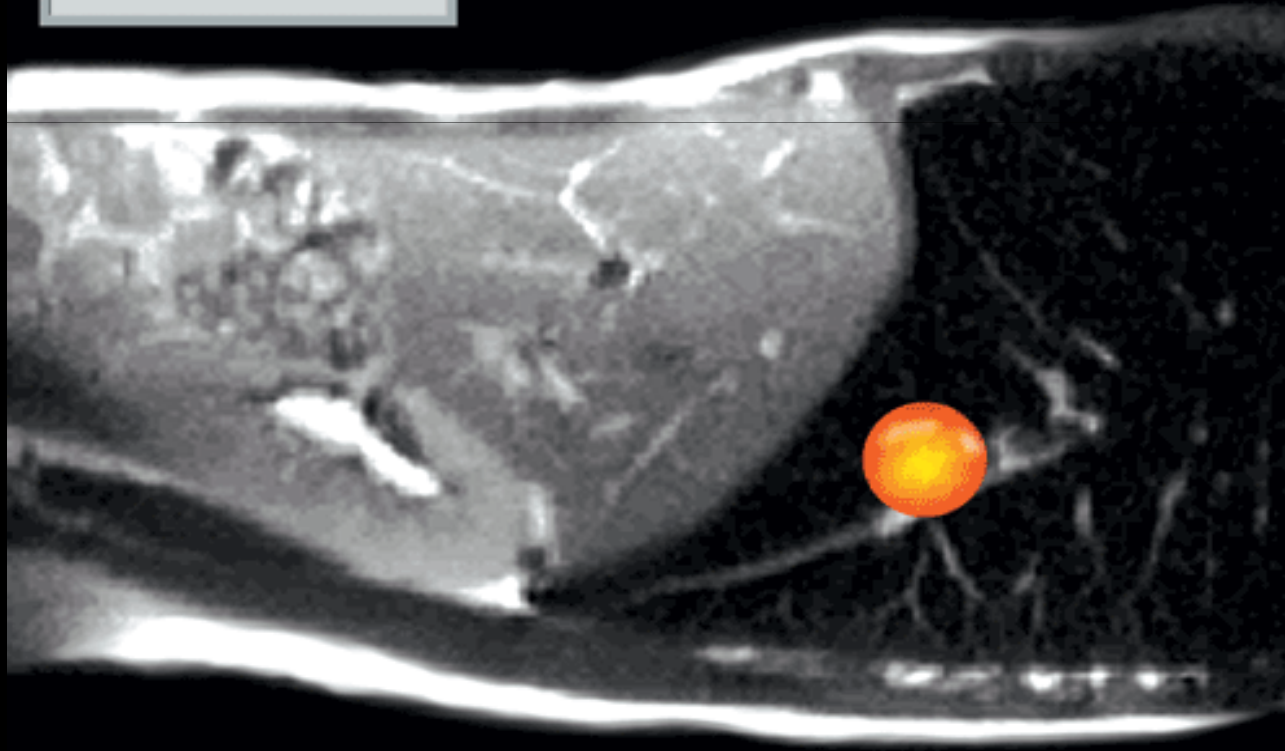
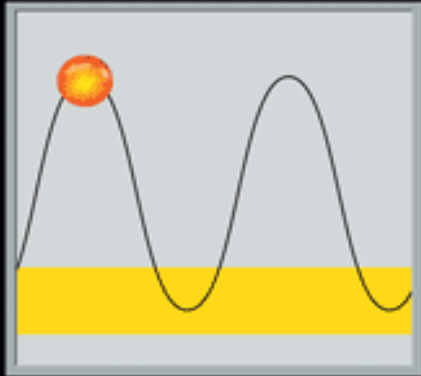
VRCT Scan/IMRT Delivery



Note: Animation does not represent actual treatment

Atención Dr. Carlos Perez

Movimiento del tumor durante respiración



Internet

4D Treatment Planning

**3D + movimiento de órgano en función
del tiempo de irradiación**

1- CT helical en inhalación

2- CT helical en exhalación

**Se irradia en la fase + conveniente
para tumor y tejido sano**

Int J Radiat Oncol Biol Phys 48 (2) pp 435-442, 2000

**Radiocirugía y radioterapia
estereotáxica fraccionada**

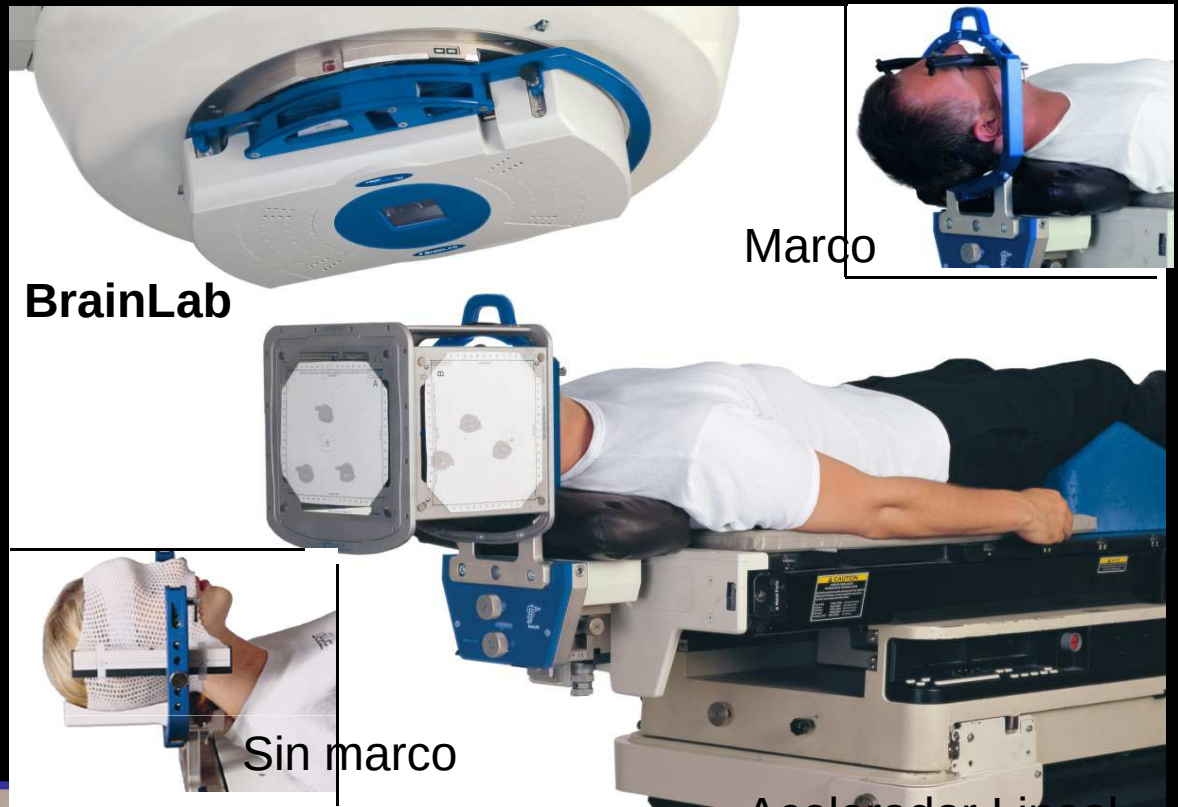
de lo tradicional a lo nuevo



**Cyclotrón
(protones)**



**Gamma Knife
(fotones)**



BrainLab

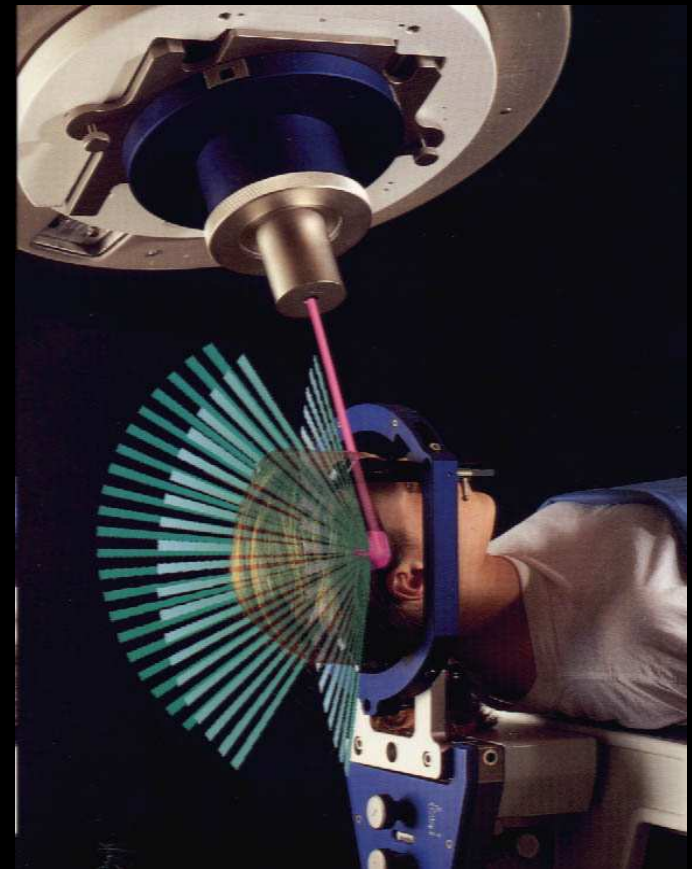
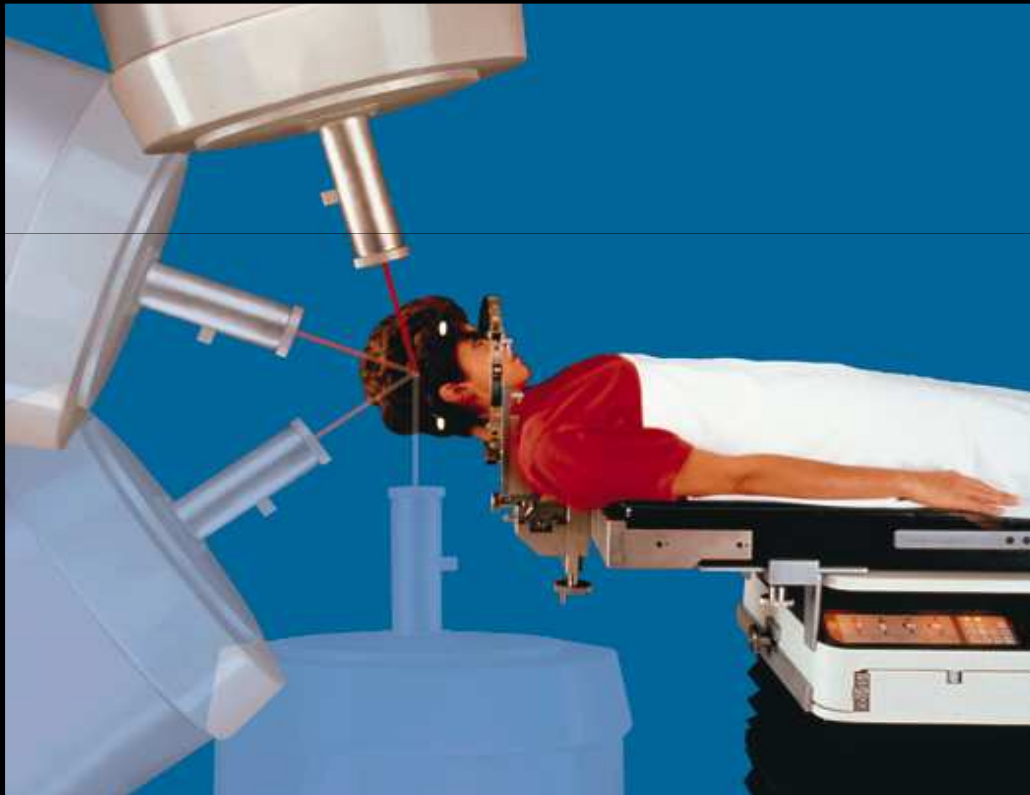
Marco

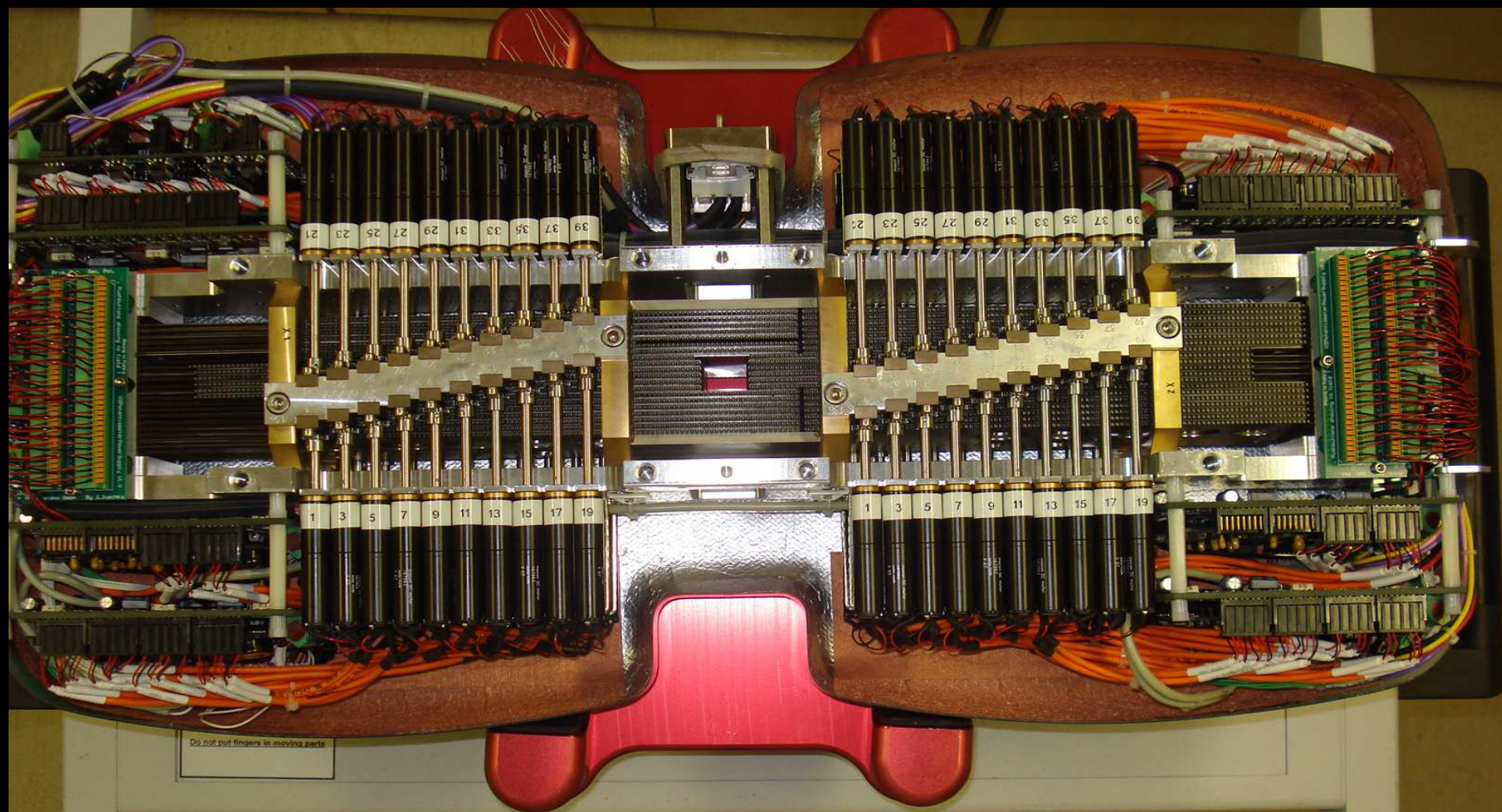
Sin marco

Cyberknife



Conos

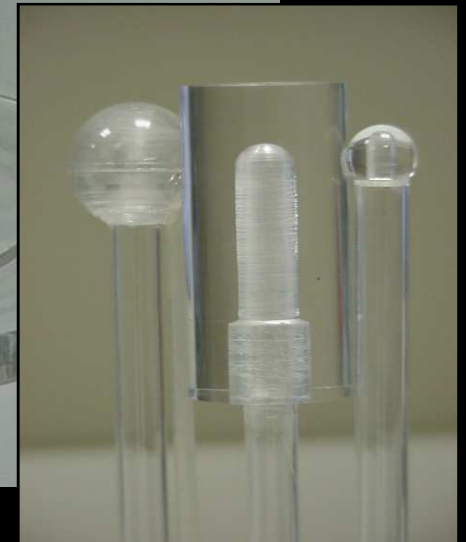
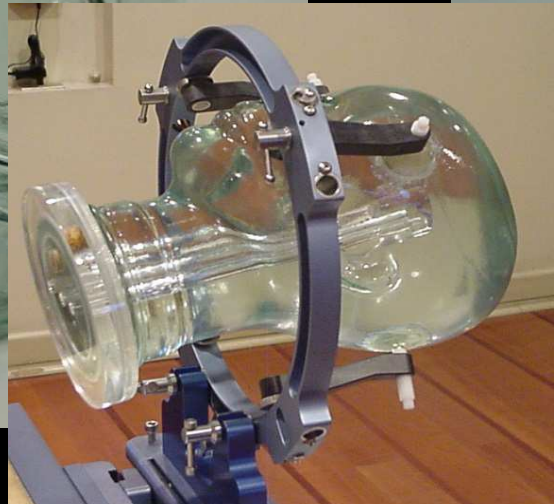




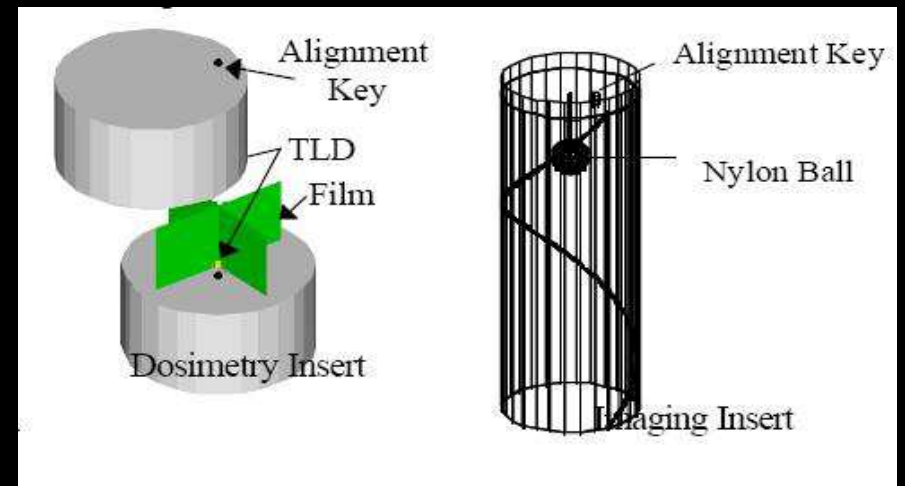
Moduleaf Siemens

Colimador micro multiláminas (80 láminas / 2.5 mm)

Verificación del sistema total



Verificación del sistema total: Auditoria externa



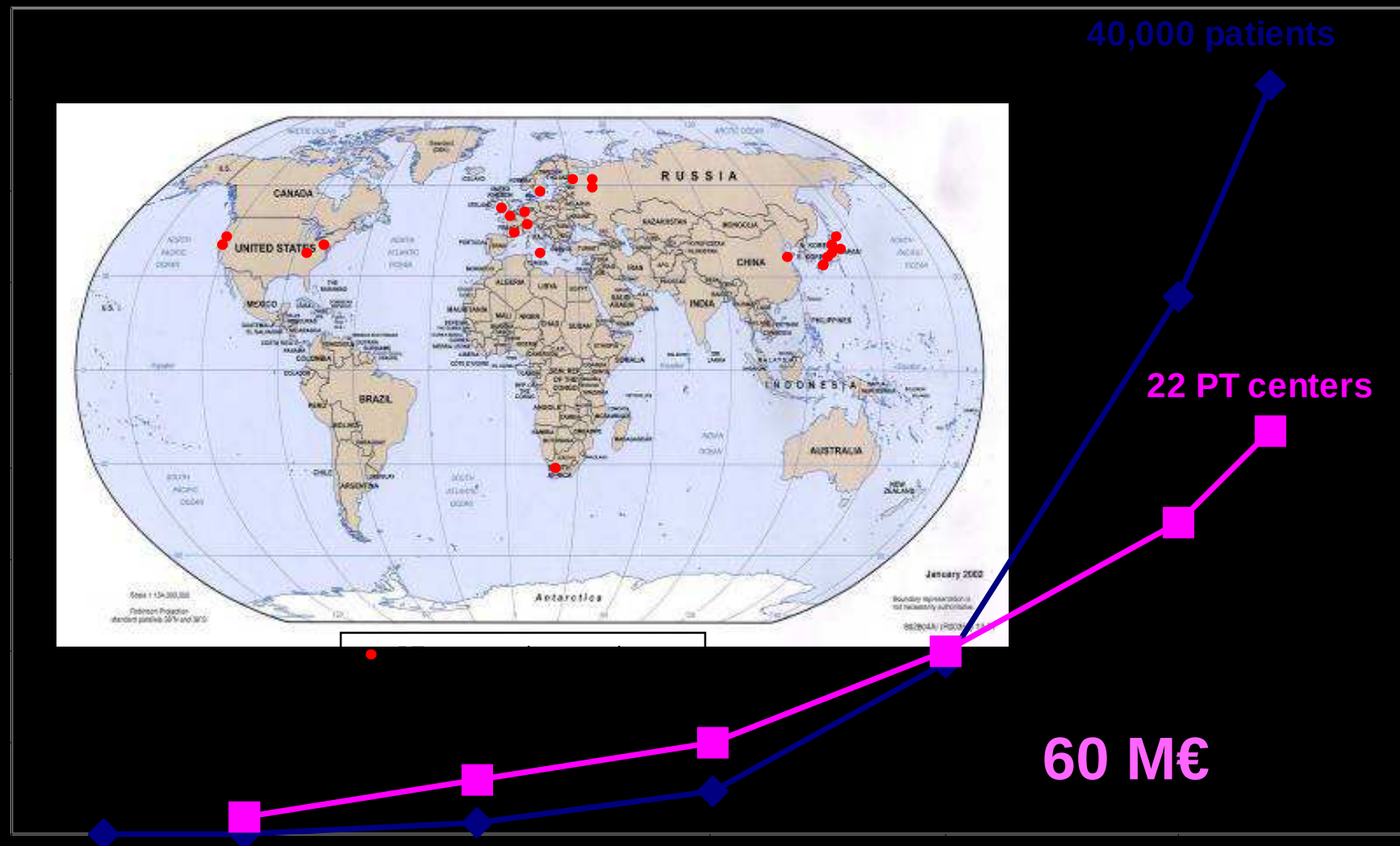
➤ Plan de acuerdo al "RTOG Quality Assurance Guidelines"

➤ Características de fantoma

- Blanco $\Phi = 19\text{mm}$ (esfera de nylon)
- Films GAF chromic MD-55 planos sagital y coronal
- 2 TLD-100 centro del blanco

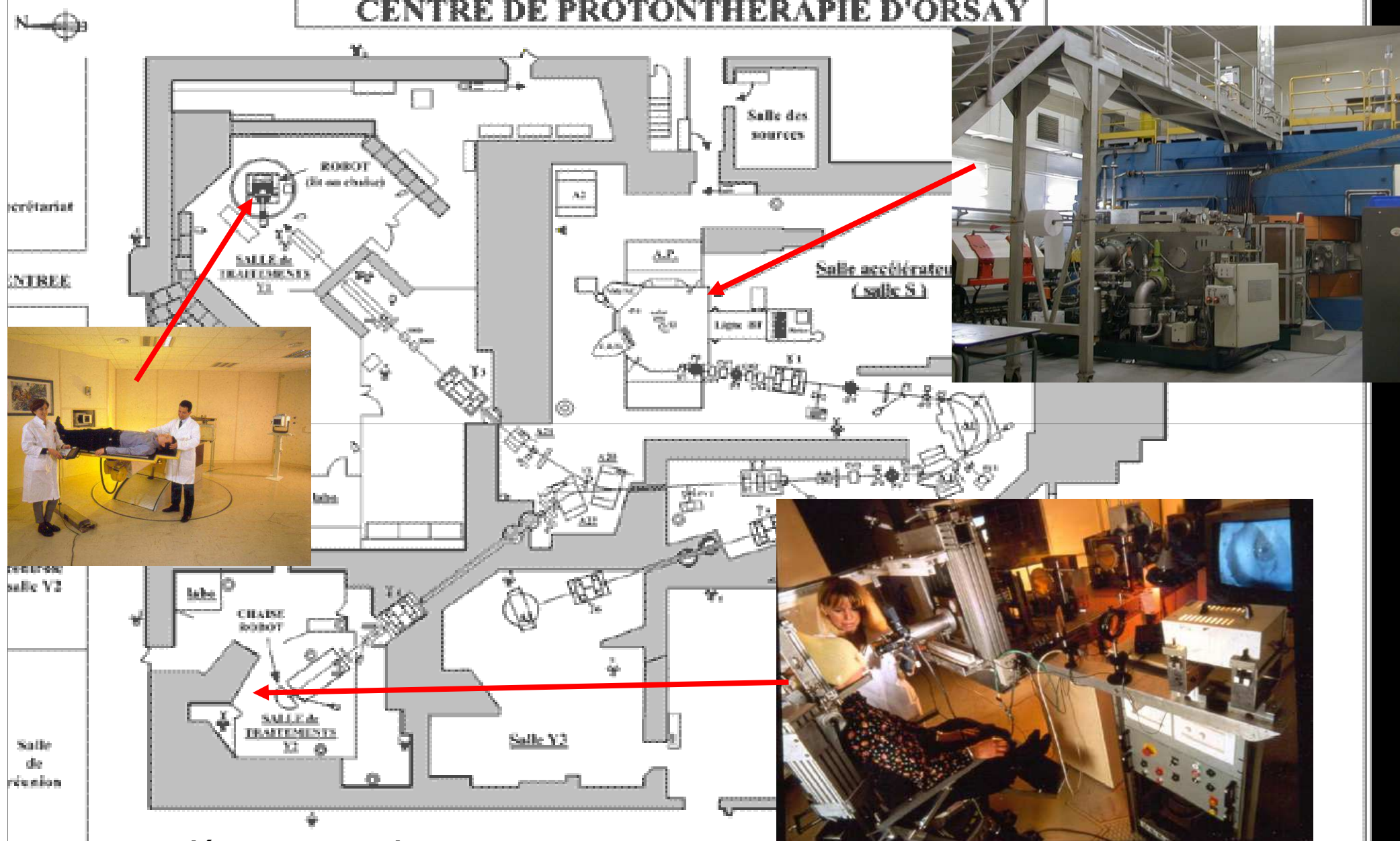
<http://rpc.mdanderson.org>

Back to Protons ...



Courtesy Janet Sisterson, MGH

CENTRE DE PROTONTHERAPIE D'ORSAY



Atención Dr. A. Mazal

Presente
“Lo Malo”

CRITICAL REVIEW

INTENSITY-MODULATED RADIATION THERAPY, PROTONS, AND THE RISK OF SECOND CANCERS

ERIC J. HALL, D.PHIL., D.SC.

Center for Radiological Research, Columbia University Medical Center, College of Physicians and Surgeons, New York, NY

Intensity-modulated radiation therapy (IMRT) allows dose to be concentrated in the tumor volume while sparing normal tissues. However, the downside to IMRT is the potential to increase the number of radiation-induced second cancers. The reasons for this potential are more monitor units and, therefore, a larger total-body dose because of leakage radiation and, because IMRT involves more fields, a bigger volume of normal tissue is exposed to lower radiation doses. Intensity-modulated radiation therapy may double the incidence of solid cancers in long-term survivors. This outcome may be acceptable in older patients if balanced by an improvement in local tumor control and reduced acute toxicity. On the other hand, the incidence of second cancers is much higher in children, so that doubling it may not be acceptable. IMRT represents a special case for children for three reasons. First, children are more sensitive to radiation-induced cancer than are adults. Second, radiation scattered from the treatment volume is more important in the small body of the child. Third, the question of genetic susceptibility arises because many childhood cancers involve a germline mutation. The levels of leakage radiation in current Linacs are not inevitable. Leakage can be reduced but at substantial cost. An alternative strategy is to replace X-rays with protons. However, this change is only an advantage if the proton machine employs a pencil scanning beam. Many proton facilities use passive modulation to produce a field of sufficient size, but the use of a scattering foil produces neutrons, which results in an effective dose to the patient higher than that characteristic of IMRT. The benefit of protons is only achieved if a scanning beam is used in which the doses are 10 times lower than with IMRT. © 2006 Elsevier Inc.

Intensity-modulated radiation therapy, Passive modulation, Pencil beams, Protons, Second cancers.

Dosimetría in vivo

Edgardo Garrigó

Alejandro Germanier

Silvia Zunino

Carla Molina

Instituto Privado de Radioterapia

Agencia Córdoba Ciencia

Unidad CEPROCOR



Córdoba - Argentina



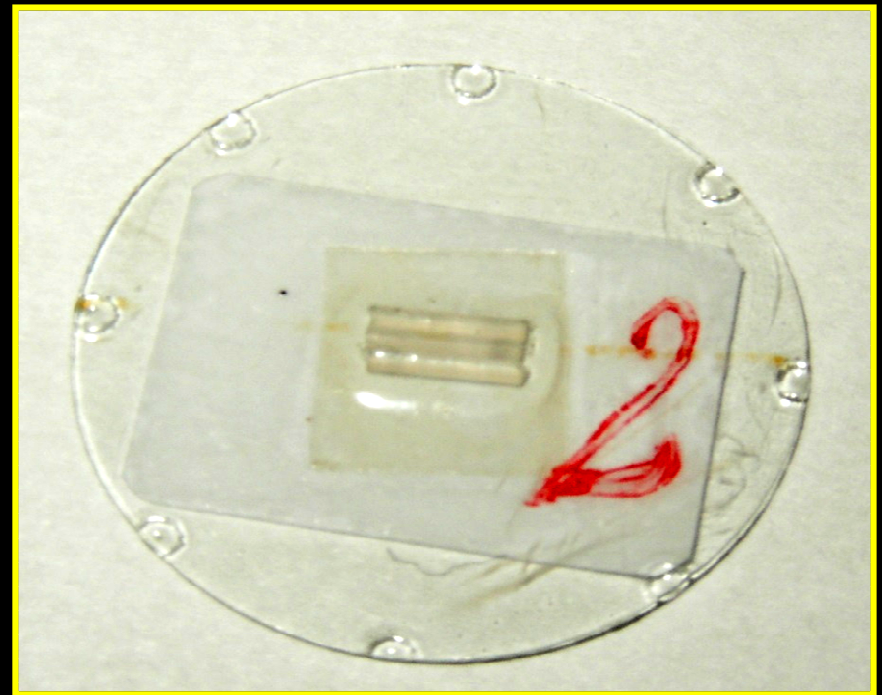
Material y Método

45 pacientes: 30 RT estándar
15 3D CRT

Dosímetro:

3 cilindros LiF:Mg,Ti Harshaw
TLD100,
(diám 1mm y
long 6mm)

Zunino, Garrigo, Germanier
Radiotherapy&Oncology 81: Suppl 1, 2006



TBI



Desde 1990

veloz avance tecnológico

lento progreso en formación

de recursos humanos

El accidente de Epinal (Francia)

- Mayo 2004 : Centro Hospitalario Jean Monnet
 - Decisión de pasar de cuñas “físicas” a cuñas “dinámicas” para la irradiación del cáncer de próstata
 - Un solo físico repartiendo su actividad entre dos centros

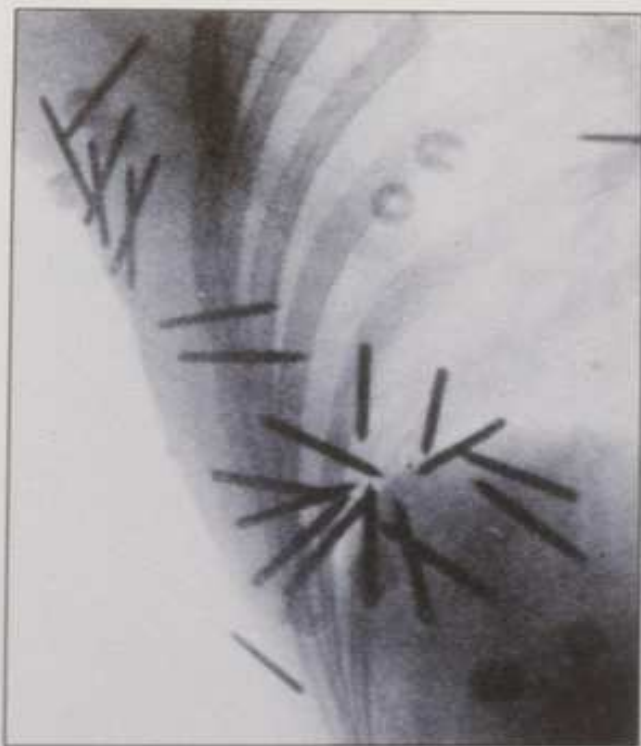


Atención Dr. Jean-Marc Cosset

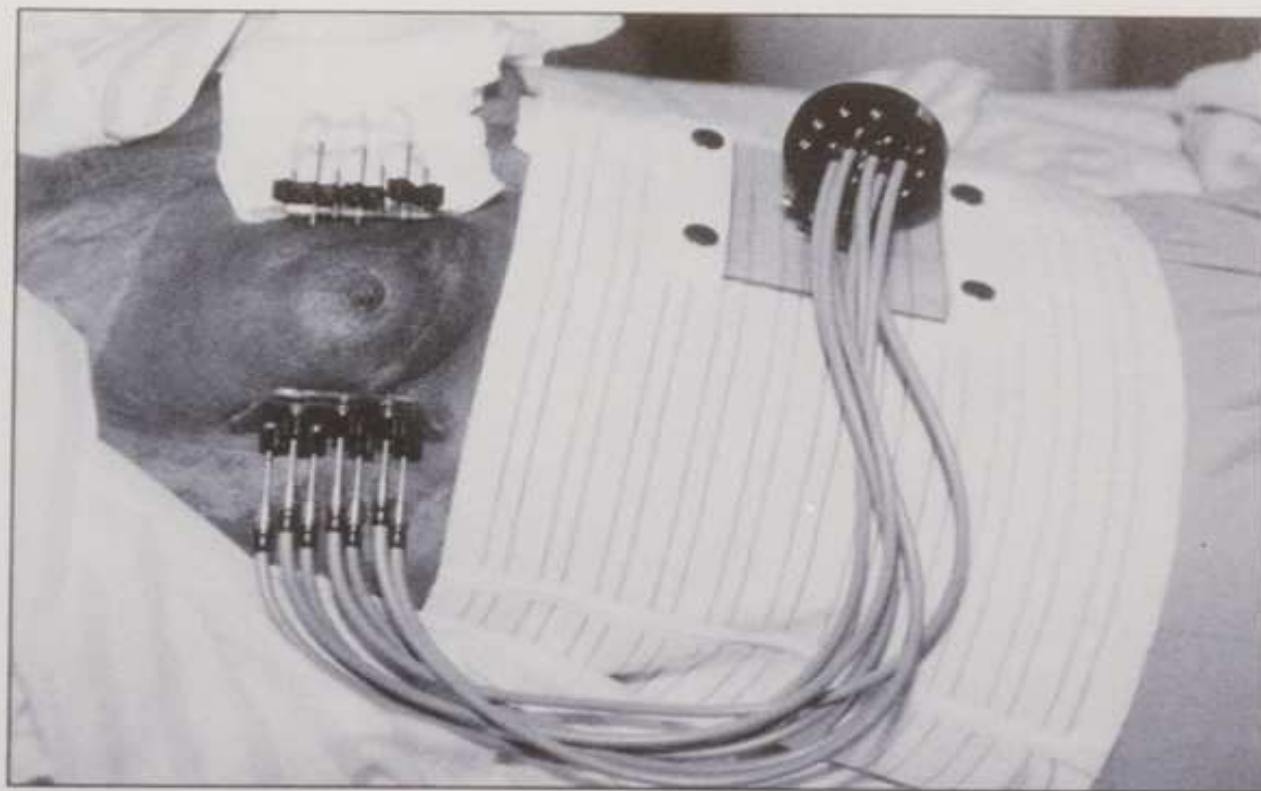
- 24 pacientes sobredosificados
- Al día de hoy, 5 decesos
- Además, varios problemas adicionales, con casos de sobredosis de 3 a 8 %, habiendo llevado a la prensa (y al Ministro!) a hablar de mas de 5 000 victimas....

Atención Dr. Jean-Marc Cosset

Más de lo bueno



[20.33] Interstitial implant for breast cancer²¹ in 1929. The radiograph shows the distribution of radium needles. The small circular shadows are beads attached to the distal end of the threads for identification purposes. In this Westminster Hospital technique, 40-50 needles containing a total of 75-100 mgm radium are inserted. The average total dose prescribed was 16,000-21,000 milligram-hours.

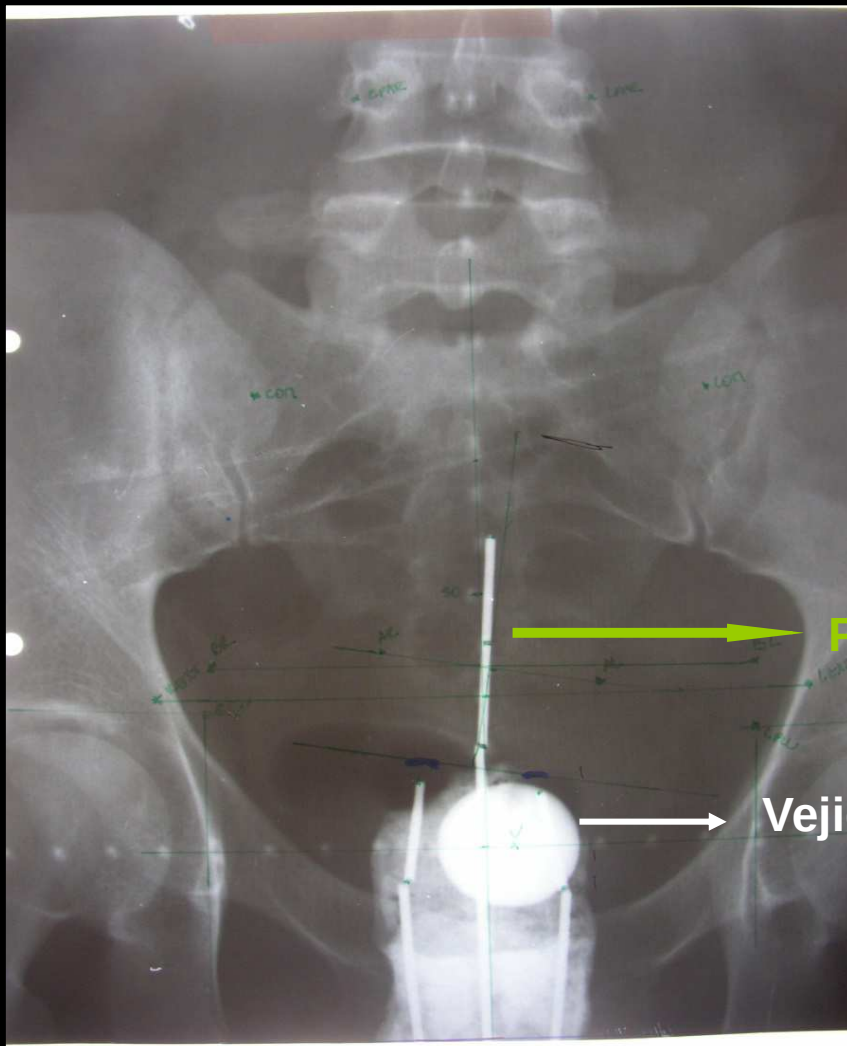


[20.34] Remote afterloading interstitial brachytherapy in the 1990s. This Academic Hospital Utrecht technique²⁸ is used for breast conservation therapy and ensures that it is not necessary for the patient to have mutilating breast surgery, such as often occurred in the first half of this century. The remote afterloading machine is the microSelectron-LDR which uses caesium-137 ribbon source assemblies. A template is used (left) to assist in positioning the needles accurately, the source transfer tubes (centre) and the afterloading coupling (right) are also shown.

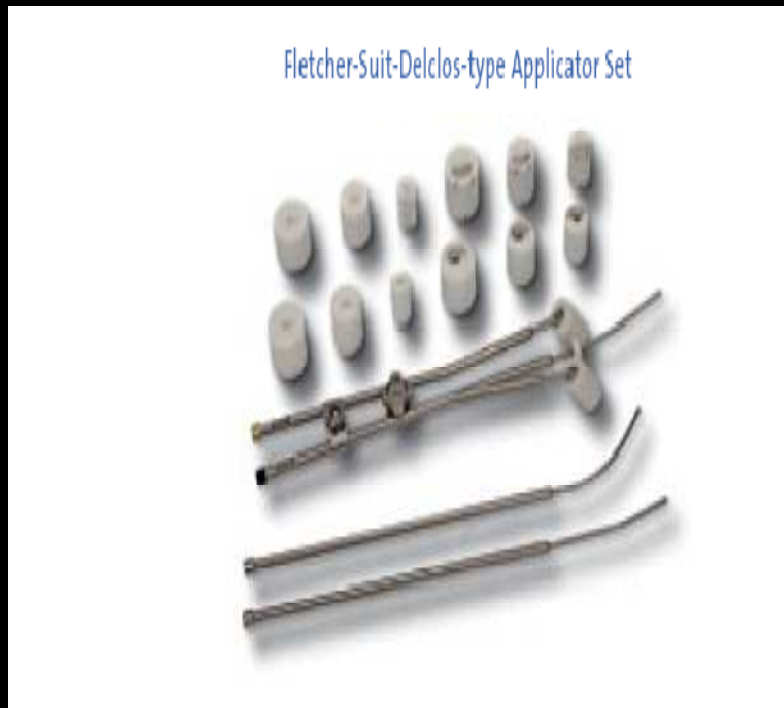


**Braquiterapia
Equipos
automáticos
controlados por
computadoras y
guiados por
imágenes**

Braquiterapia Baja Tasa de Dosis

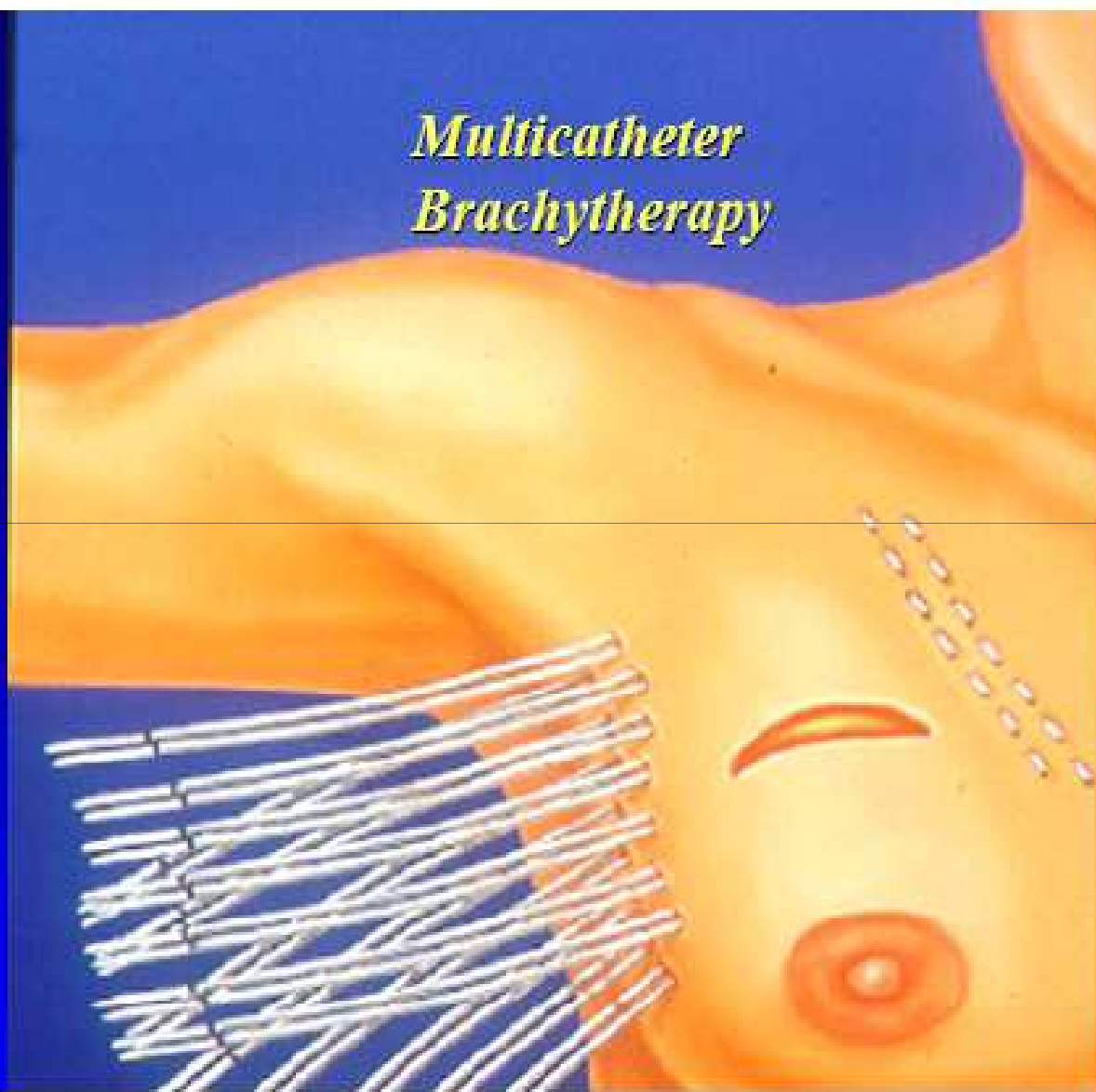


Braquiterapia Alta Tasa de Dosis



**Lo muy nuevo
con corto seguimiento**

*Multicatheter
Brachytherapy*



MammoSite Radiation Therapy System

- present balloon size - additional sizes and shapes planned

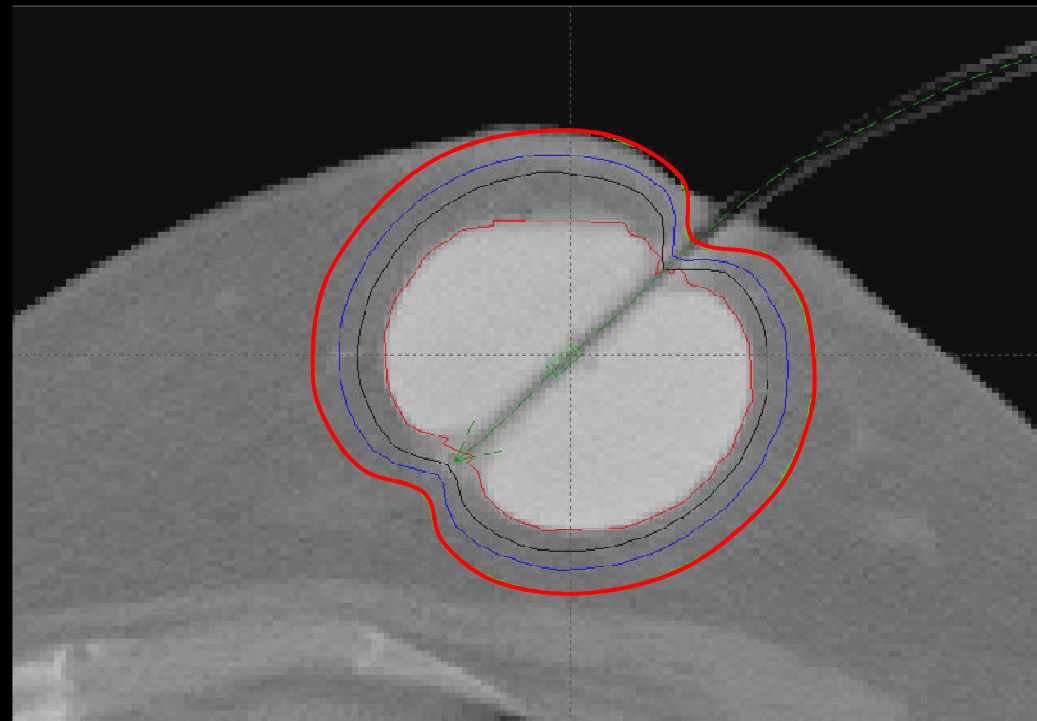
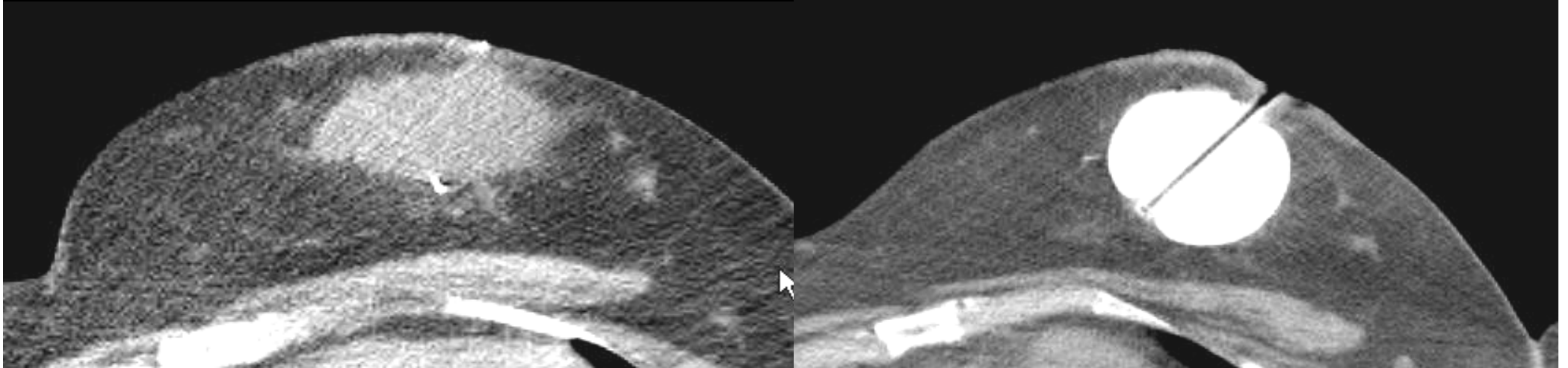


15cm length
6mm diameter



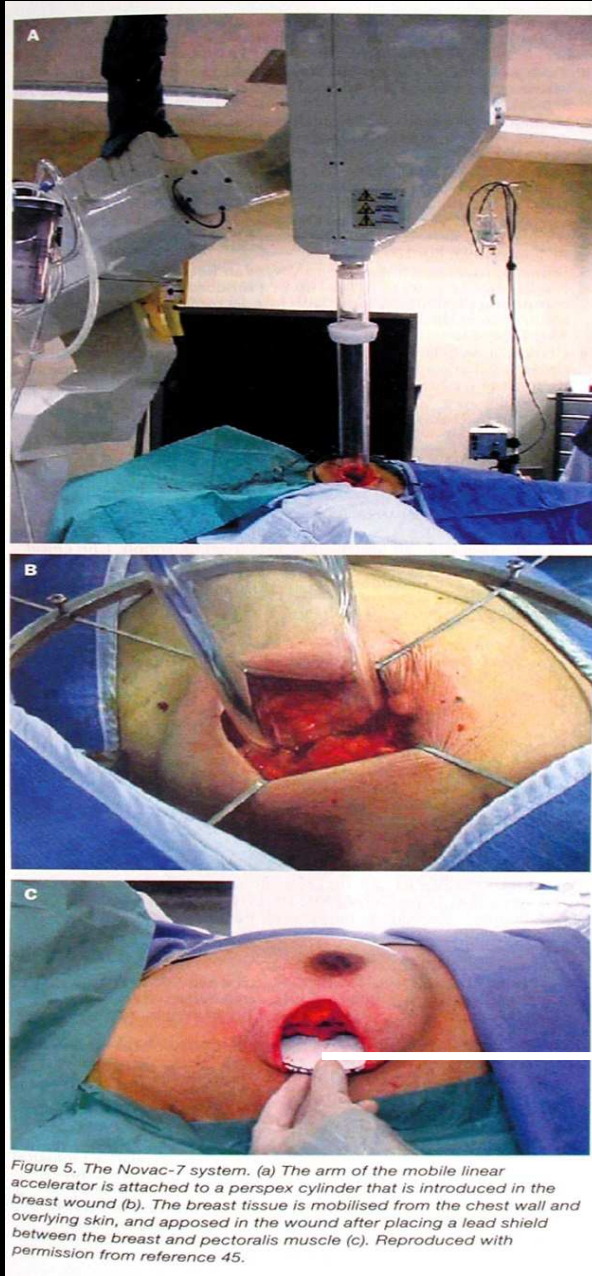
Spherical
4 to 5 cm (35 - 70 cc)

Ideal Case for MammoSite



Novac – 7 (Milán)

The Lancet Oncology
(5)165-173, 2004



→ Protección pared
Aluminio + Plomo

Futuro

El progreso tecnológico continuará

Necesitamos asegurar

- **Protección del paciente**
- **Formación de recursos humanos**
- **Investigación en dosimetría, efecto biológico, fraccionamiento y técnicas**
- **Evaluación de cada paciente**
Riesgo / beneficio y costo / eficacia
- **Garantía de calidad del tratamiento**

Cáncer primera causa de muerte 2010

> 60% recibe radioterapia

Nueva Tecnología + Capacitación

```
graph TD; A[Nueva Tecnología + Capacitación] --> B[Disminuye toxicidad]; A --> C[Prolonga SV]; B --> D[Mejor calidad de vida];
```

Disminuye toxicidad

Prolonga SV

Mejor calidad de vida

Gracias

Acad. Rubén Bengió

Autoridades

Acad. Hugo Maccioni

Acad. Zenón M. Sfaello

Acad. Clelia M. Riera

**A todos los Académicos que aceptaron
mi incorporación**

A los amigos que me acompañan